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INTERNATIONAL CONFERENCE ON MECHANICS OF SOIL-VEHICLE SYSTEMS

The First International Conference on the Mechanics of Soil-Vehicle Systems will be held in Turin, Italy, in June 1961. The Conference will be sponsored by the Turin Institute of Technology in cooperation with the Italian Army, the Italian National Research Council, and the U. S. Army Office of Ordnance Research, Duke University. The purpose of the Conference is to discuss on an international forum the present concepts of the mechanics of land locomotion, as well as their engineering aspects. The Conference will last 4–5 days and will have a number of papers selected by the Organizational Committee. The United States, West Germany, France, England, Japan, Canada, Holland, and Israel have thus far agreed to participate.

Persons interested in attending or submitting a paper should write Headquarters, U. S. Army Ordnance Tank-Automotive Command, Land Locomotion Laboratory, 1501 Beard Street, Detroit, Michigan.

Do You Know

► That copies of Teaching Tomorrow's Engineers are available for free distribution to graduate students and qualified undergraduates? Every college of engineering is expected to use this booklet in recruiting graduate students, teaching assistants, and full-time staff members. Unless you encourage them, qualified students most probably will overlook graduate work and a career in engineering teaching. If your dean doesn't keep a supply on hand, needle him a bit and have him submit a request. After all, they are free!

► That the members of the Projects Management Group have been named? They are L. E. Grinter, B. R. Teare, Jr., O. E. Lancaster, H. A. Foecke, W. W. Harmon, A. R. Spalding and J. A. Hrones. In appointing the Committee, President E. A. Walker charged it with the responsibility to receive from Society members (individual or institutional) proposals for research or study of engineering education; to initiate proposals which seem to be in the broad interest of the Society; to review all pending proposals from time to time and determine which should be given Society sponsorship; to submit approved proposals to appropriate foundations and to other agencies for consideration and support; to choose and employ, through the Society, project directors and any other necessary operating personnel; and to review from time to time the progress of all projects. This means that the Committee will manage Society projects rather than expect that it would be done either by the officers or an *ad hoc* committee of sorts. ASEE has allocated $5000 to get the Committee going, but it is hoped that before long the Committee and its activities can be financed from non-ASEE funds.

► That deans of engineering list three main causes for the decrease in freshman engineering enrollments during the past two years? They are the increased interest by qualified students in other fields of science, especially since "science and the space age" have been glamourized in public opinion; concern over the rigors and demand of engineering education; and decrease in applications from students lacking in genuine interest and motivation for engineering. The same factors also generally account for the increased attrition rate among engineering students. These results come from a study made by the Engineering Manpower Commission of Engineers Joint Council, which submitted a questionnaire to the 231 U. S. colleges offering degree-credit engineering courses. 151 schools responded. An increasing number showed an increased attrition rate, but the survey also revealed that on the positive side the problem of accepted students not enrolling in the fall had decreased. The proportion of accepted applicants registering increased over that from 1958–59. EMC believes the 1960–61 freshman enrollment will be larger than that of 1959–60. Among the deans there also was a general consensus of the need for the engineering profession to establish more effective means of communicating to young people facts about engineering, its importance, and its rewards.

► That a six man delegation spent a month in the USSR last summer studying the utilization and allocation of Soviet engineers and technicians? Three of the six, W. E. Lobo, Chairman, H. Russell Beatty, and S. B. Ingram, are ASEE members. A Russian delegation will visit the United States at a later date. The project is being carried out by the Engineers Joint Council under the sponsorship of the National Science Foundation and the U. S. State Department.

► That the National Science Foundation celebrated its tenth anniversary last June? During that time its allocations have grown from 3½ to 152 million dol-

lars per year. Congratulations are extended to Dr. Waterman and his staff, and in particular those who from time to time have worked so tirelessly on the engineering aspects of the programs.

► That President E. A. Walker is one of five new appointees recommended by the President of the United States for a regular six-year term on the Board of the National Science Foundation? The other appointees are three chemists and a geologist. The three reappointments for six-year terms are two physicists and a clergyman. For filling unexpired terms a sociologist and a historian were recommended. Such is the challenge of the engineer.

► That the next closing date for receipt of proposals for support of renovation and/or construction of graduate level (doctoral) research laboratories is expected to be March 1, 1961? A 50% participation by the institution with funds derived from non-Federal sources is required. Apparatus and equipment are not included; only departments with an ongoing program leading to the Ph.D. are eligible, and facilities primarily for instructional purpose will not be considered. Preliminary inquiries should be directed to the Office of Institutional Programs, National Science Foundation, Washington 25, D. C. About $2,154,000 were granted to 54 colleges and universities last year in order to alleviate obsolescence and, in many cases, the total inadequacy of existing graduate research laboratories.

► That the area of knowledge which studies various aspects of research activity as it affects the growth of human culture is called zetetics? Another way of saying the same thing is "Research as a Science." A book on the subject has been written by S. T. Tykociner, Professor Emeritus of electrical engineering at the University of Illinois. The preliminary publication consists of the first two parts of the total work. In part one the principles and aims of the science of research are treated, while part two contains an inventory of sciences, a catalog of old and new sciences with their branches, and also the arts. The two additional parts are in the course of preparation, part three including the zetetic tables and part four treating zetetics in relation to social development. Copies may be obtained by writing to Professor Tykociner at 306 West Iowa Street, Urbana, Illinois. The cost is $2.00 per copy.

► That "Education and Nuclear Energy" is a new 61-page booklet of the International Atomic Energy Agency? It reports on a seminar held July 6–10, 1959 in Saclay, France, attended by 80 participants from 31 countries. Copies costing $1.00 each may be purchased from the National Agency for International Publications, Inc., 801 Third Avenue, New York 22, N. Y.

► That two important international meetings in the field of experimental mechanics will be held in this country in the fall of 1961? An International Symposium on Photoelasticity will be held on October 29–31, 1961, at the Illinois Institute of Technology. An International Congress on Experimental Mechanics will be held November 1–3, 1961, in New York City. Papers for both conferences should be submitted prior to January 31, 1961, to Dr. P. D. Flynn, at IIT and Dr. Roscoe Guernsey, Jr., General Engineering Laboratory, General Electric Company, Schenectady 5, New York, respectively.

► That the next International Navigation Congress will be in Baltimore in 1961? The sponsor of the Congress, held every four years, is the Permanent International Associatoin of Navigation Congresses, PIANC. Membership is open to individuals, libraries, schools, corporations and others interested in the exchange of views and experiences on world problems relating to harbors and inland waterways. For additional information write to the Secretary of the American Section, PIANC, c/o Board of Engineers for Rivers and Harbors, Washington 25, D. C.

► That a Scandinavian Documentation Center, SCANDOC, has been established in Washington, D. C.? Its purpose is to further the mutual exchange of science-technical information and documentation between Scandinavian countries of Denmark, Finland, Norway and Sweden, and the U. S. and Canada. It is a non-profit organization rendering free service to all interesed parties and will procure non-classified and non-confidential documents and information and channel this to the respective interested countries through information offices organized under the research councils and academies of the countries. Mr. Arne Sverdrup is in charge of the office at 2136 P Street, N.W.

► That "Research and Development, Economic Growth, and National Security" and "Opportunities for Graduate Study and Research in the Resources Field" are two new reprints of Resources for the Future, Inc.? The former is reprint No. 17 by H. J. Barnett and the latter is reprint No. 16 by R. G. Gustavson. Single copies are free on request, but additional copies cost 25¢ each. The address is 1145 Nineteenth Street, N.W., Washington 6, D. C.

► That the International Business Machines Corporation has just established an IBM Systems Research Institute? It is being done to increase sharply the number of computer professionals in the U. S. and will offer work on the graduate level. The purpose is to train people to find computer system solutions to complex business and scientific problems and the curriculum will include subjects such as case studies in systems-design, workshops in systems planning, advanced programming, and business stimulation techniques. The faculty will include senior IBM systems people and visiting lecturers from industry and leading universities. The director of the Institute will be IBM vice president J. C. McPherson. The annual budget is about $2 million. The first group of 30 students will be enrolled in the fall of 1960. Eventually it is expected to train up to 400 people a year.

► That there were three engineers among the 35 members elected to the National Academy of Sciences last April? They are Professor H. G. Booker of the Electrical Engineering Department of Cornell University, A. B. Kinzel, Vice President in Charge of Research of Union Carbide and Carbon Research Laboratories, Inc., and President of EJC, and E. J. Wiesner, Director of Research Laboratory of Electronics at MIT.

► That a "Study of Student Evaluation of Teaching" has been approved by the American Council on Education and it is now seeking a grant of about $28,000 for the support of the study?

► That the proceedings of the Fifth Annual Conference on University Contracts Abroad has been published by the American Council on Education under the title, "Toward a Foreign Policy for Higher Education"? The report contains a full text of papers presented at the general sessions as well as the addresses delivered by Senator Jacob K. Javits and President Henry T. Heald of the Ford Foundation. Copies may be obtained from the Publications Division of the American Council on Education, 1785 Massachusetts Avenue, N.W., Washington 6, D. C. for $1.00 each.

► That life members of all societies are said to be in favor of increased dues? The reason is that the higher the dues go the more money they save.

► That bit by bit evidence is accumulating that the quality of articles in the JOURNAL is increasing? The latest is a request from the National Education Association to reprint "Teaching Machines" by D. J. Mayhew and A. F. Johnson in the forthcoming book, *Teaching Machines and Programmed Learning. A Source Book*, edited by A. A. Lumsdaine and Robert Glaser. The book brings together what the editors believe to be "the most significant articles in this field published in the last four decades."

W. LEIGHTON COLLINS
Secretary

Understanding the Academic World

W. H. COWLEY

David Jacks Professor of Higher Education, Stanford University

Foreword for CDEF Cleveland Conference November 19–21, 1959

What engineer would think of undertaking a new and unfamiliar engineering assignment with no more explicit preparation than we customarily expect of a young instructor meeting his first classes? We assume, usually with justification, that he is bright and has a good command of professional subject matter, but what about those personal qualities and skills by means of which rapport with his students is established? Does he, in fact, have even the elementary classroom skills, without which he is awkward and his students embarrassed? In the broader view, it borders on absurdity to expect, at this stage, any grasp of the evolution of educational thought in his profession, in his institution, and in his department.

Our normally negative replies to such questions result not so much from gross negligence, as from the low availability of the resources in the field of education for engineering teachers.

Yet the Committee on the Development of Engineering Faculties is convinced that we can, and must, as we meet the accelerated demand for more new engineering teachers, make wider use of and increase the resources we have to help the neophyte instructor develop most rapidly into a strong engineering educator.

The purpose of the CDEF Cleveland Conference, 19–21 November, 1959 was to identify and assemble these resources that are available, from our own and other fields, including professional education, to assist our young instructor in achieving a productive and satisfying competence as a teacher with minimum delay and unfruitful struggle.

This paper is one of a series of such contributions to our profession at the CDEF Cleveland Conference.

What should an educator, not just an engineering educator but every educator, know about the academic world? I suggest that he ought to have some knowledge of the answers to such questions as these: Why do colleges and universities exist? What do they do? How do they go about accomplishing their tasks? Why do they do what they do?

Why Colleges Exist

The first question—why do colleges and universities exist—cannot be answered just by surveying the present scene. Many institutions have venerable histories which must be understood in order to understand why society established them.

The history of higher education in the western world extends over some twenty-three centuries. The Academy of Plato established in 387 B.C. continued in operation for 918 years, or longer than any modern university has been in existence. The great museum [1] at Alexandria lasted for 942 years and during its early centuries (it opened in 342 B. C.) surpassed all centers of learning in history until the nineteenth century. The Moslems op-

[1] *Museum* in the ancient world meant "home of the muses," the patronesses of learning.

erated the greatest university of the Middle Ages at Cordova, Spain; and the Christian universities established later came upon the scene in part because of the stimulation of Cordova and other comparable Moslem institutions. Most historians until the recent past taught that the Moslems were barbaric people devoid of learning. Few do now, and increasing numbers emphasize the debt of European scholarship and education to Moslem antecedents.

Knowledge of the contributions of Moslem learning has significance today because it illuminates both the history of research (a university function which Moslem scholars and scientists recognized) and the history of liberal or general education. Concerning the latter the myth has long flourished that a sound general education must be grounded on the seven liberal arts because Plato and Aristotle declared them to be indispensable, fundamental. The fact is, however, that Plato and Aristotle never heard of the seven liberal arts. That curricular entity did not take form until the fifth century after Christ, and it did not include many subjects (the social sciences in particular) which Plato and Aristotle vigorously promoted. Most historical scholars now agree that the curriculum of the seven liberal arts flourished during the Dark Ages and that universities did not appear in western Europe until they had been superseded.

I cite the seven liberal arts myth because fallacious history frequently leads to fallacious decisions about present-day problems. Let me illustrate this generalization with an example from the history of American higher education. Ask almost anyone in the academic world about the purpose of the colonial colleges, and ninety-nine out of a hundred will assert that they had been established for the primary if not sole purpose of educating ministers. Recent studies, however, have demonstrated this to be quite incorrect, as witness the fact that the charters of seven of the nine colonial colleges make no mention at all of the training of ministers but, instead, declare their purpose to be, in the words of the Harvard charter, "the advancement of all good literature, arts, and sciences." In short, they were established to supply the nation with educated men to serve, in the words of the Yale charter, both "church and state." Further, all the colonial colleges emphasized education for breadth, not for a single vocation. Failure to comprehend this fact has again and again led to unwise decisions about the purposes of American higher education in general and of particular institutions.

So much for history. It throws definitive light, I suggest, upon the reasons that colleges and universities have been established; but now the question about the reasons why higher educational institutions arise in a society must be faced more directly. As I see it, the answer is this: all colleges and universities have been established by a power group which desires to maintain and to propagate its point of view. This is true of institutions in democratic countries as well as all others. Colleges and universities exist, in short, to put the culture of the educating group into those being educated, a process that the anthropologists are coming to call enculturation. The power group may be a nation, a political subdivision of a nation, a church licensed by civil government to operate a college, a group of private citizens or even a single citizen similarly licensed by civil government. Single citizens, of course, must appoint trustees who thereupon become the power group.

I wish time permitted an expansion of the legal considerations involved in the establishment and operation of American colleges and universities. Since it doesn't, I'd like to make one brief observation about the fact that our pluralist conception of government permits any group to establish and operate an educational institution provided its sponsors do not advocate the overthrow of the Constitution. This fact, inherent in the First Amendment to the Constitution and confirmed by the Dartmouth College Case of 1819, accounts for the unique American systems of public and private education functioning side by side and usually cross-fertilizing one another. In my judgment our American educational pluralism

constitutes one of the greatest strengths particularly as it affects higher education.

Much more important for present purposes, it seems to me, is the concept of enculturation, which probably hasn't come to the attention of most engineering educators. Recall that enculturation consists in the activities of an educating group in putting its conception of culture (that is, ways of thinking, feeling, and doing) into the students whose education it directs. The word *culture* may be a red rag to some engineers, but I hasten to point out that two kinds of culture must be distinguished and dealt with. The first is general culture, the second special culture; and engineers as individuals, of course, have some of both: merely by living in the United States they have absorbed a great deal of general American culture, and this has been enhanced by their formal studies in school and college; they also have the special culture of the engineering profession, a culture which only engineers share; and further, all engineers today specialize, and so each engineer has the special, special culture of his sub-division of the profession.

This rapid sketch of the nature of enculturation makes it possible, I suggest, to answer fairly succinctly the question of why colleges and universities exist. The answer seems to be that nations and groups within nations have found that higher educational institutions constitute the most economic means of accomplishing the higher general enculturation of its best endowed citizens as well as the special enculturation of its higher-level workers—its administrators, engineers, lawyers, physicians, and other so-called professional workers.

If educational institutions constitute society's best method of promoting general and special enculturation, then it would seem to follow that all those engaged in the business of education ought to know something about the significance and processes of enculturation. In particular engineering educators should know more about enculturation than most do for the reason that as a group they've never been able to come to conclusions about the desirable relationship in engineering education between efforts to further the general enculturation of engineers and those concerned with their special enculturation. Further, engineering educators are also continuously concerned with the ingredients of their special enculturation.

What Colleges Do

I'd like to continue to discuss enculturation, but perforce I move on to the second of the four questions asked in my opening paragraph, namely, what do colleges and universities do?

To begin with, they enculturate, that is, educate. But they do a lot of other things, too, and these things can be called *functions*. The anthropologists and sociologists define this term in several ways, but the most useful definition seems to me to be this: a function is a characteristic activity of anything, be it a screw driver, a person, or a social institution. If you'll accept this definition, then the discussion can move on to the problem of classifying the functions of colleges and universities. The classification will help answer the question, "What do colleges and universities do?", and it will also prepare the way for the third question about how they go about accomplishing their tasks.

My students and I over the past fifteen years have come to the conclusion that the functions of higher educational institutions (and of most other kinds of social structures) fall into three groups. The first of these we call *raison d'ĕtre* (reason for being) functions, the second complementary functions, and the third self-continuity functions.

Few will disagree, I think, that colleges and universities have only two *raison d'ĕtre* functions and that they are teaching and research. Other institutions perform these activities, but none undertakes them as *raison d'ĕtre* functions. Some large corporations, for example, operate schools, General Motors Institute in Flint, Michigan, being a case in point. Such enterprises, however, are complementary functions of business corporations, functions undertaken to facilitate their *raison d'ĕtre* function of supplying goods and services to customers. Sim-

ilarly increasing numbers of corporations employ research people, but with them research is a means to the end of new or improved products. In sum, only colleges and universities have the *raison d'ĕtre* functions of teaching and research.

Just as teaching and research are complementary functions of business corporations, so also colleges and universities perform a number of complementary functions. For example, they give honorary degrees, a very important function in this country because we have nothing comparable to the honors list of Britain which makes outstanding people knights, barons, lords, etc. American colleges and universities also perform the highly valuable forum function, the function that makes available their platforms for public discussion and also for the public announcement of important public policies. Thus Winston Churchill signalled the change in British and American attitudes toward Russia in a speech at Westminster College in Missouri; General Marshall announced the inception of the Marshall Plan at a Harvard Commencement; and President Eisenhower put himself on record against Senator McCarthy for the first time in a speech at Dartmouth.

Higher educational institutions perform a dozen or so complementary functions, each of which it would be interesting to cite; but I must move on to the third category, to wit, the self-continuity functions. These consist of the functions in which a social institution engages in order to survive, to continue in existence, to make possible the performance of its *raison d'ĕtre* and complementary functions.

In this category falls everything called administration—all activities from buying chalk and cleaning blackboards to raising money and making top-level policy decisions. I needn't, I'm sure, even attempt to list these diverse functions. Enough, perhaps, to say about them that they are *means* functions and not ends in themselves, a fact that administrators and their minions (janitors and library clerks, for example) seem sometimes to forget.

The title of this paper is "Understanding the Academic World," and I submit that engineering educators should possess a knoweldge of college and university functions—including their classification, interrelationships, and also the frictions between and among them.

How Colleges Work

The third question relates to how colleges and universities go about accomplishing their tasks. The topic has far-flung ramifications relating, in the first place, to the processes involved in its functions, and second, to the organization of American institutions of higher education. Concerning the first I shan't say anything because obviously I'd have to speak for hours on end just to scratch the surface of the topic of the processes involved in the teaching function, never mind the research function and the scores of complementary and self-continuity functions. Without taking too much time, however, I can say a bit about the structuring or organization of American higher education. It differs markedly from that of other countries.

The most glaring fact about the structuring of American higher education is probably its diversity. We have universities, colleges, junior colleges, technical institutes, and a score of other varieties of structures. Nothing like such diversity exists anywhere else in the world, and we ourselves have a difficult time classifying our higher educational structures. For example, M.I.T. is called an institute, but really it's a university not only in scope but also in the quality of its work in fields far removed from engineering—economics for example. Thus it's a member of the top-most educational organization in the United States, the Association of American Universities, which has only forty-two members. At the other end of the scale we have junior colleges which call themselves universities but which are so poor in quality that they're not even accredited as junior colleges.

American higher educational diversity results from a number of considerations, the two most important of which seem to me to be our national dedication to the idea of equality and the primacy of the states, as opposed to the federal gov-

ernment, in education. The idea of equality has led to the establishment of a variety of qualitative levels in higher education with the result that youngsters of even lower than the national average of intelligence (that is I.Q. 100) can get into college *somewhere*. This is another way of saying that we have some very, very colicky colleges, a fact which many of the American intelligensia find oppressive and which Europeans generally deplore. For my part, I think their existence a small price to pay for the values of American equality, but I shan't debate the point. Instead, I move on to discuss briefly the point that the states rather than the federal government dominate American education on all levels.

The states not only have established public institutions for higher education but all of them have chartered private colleges and universities. These, as observed, differ in quality depending upon a large number of factors including the wealth of the state, the wealth and geographic spread of their alumni, whether their support be public or private, etc. Further, and more important in this present context, is the range of their *raison d'être* functions. Junior colleges have a range limited by the two-year span of their curriculums; liberal arts colleges have four years to work with their students, but they do relatively little with professional education and less with the research function; universities, in turn, differ in both the spread of the kinds of education they make available to students and the research they undertake. Thus diversity abounds.

In this diversity, however, there has arisen a new kind of university, a kind of university never before put into operation anywhere. I mean *the comprehensive university*, a uniquely American structure. To explain it I must again cite a bit of history.

The historic university which evolved in western Europe during the late Middle Ages had four divisions, called faculties: one each in divinity, law, medicine, and philosophy or the general arts and sciences. When knowledge began to proliferate in the late eighteenth and the nineteenth centuries, European universities did not choose to admit such new subjects as agriculture, engineering, business administration, and pharmacy but, instead, forced those interested in the advancement of these subjects to establish new non-university structures. In short, they considered the new subjects unworthy of places in universities.

Americans followed these European academic prejudices, by the way, until the passage of the Land Grant College Act in 1862; and some forty unitary engineering schools continue in operation today as vestiges of the contempt of European university people and their American adherents for the mundane subject of engineering. Many of these forty, of course, have become notable and eminent; and I do not mean to criticize them. Instead, I want to point out that we no longer establish unitary professional schools in the United States in any subject but, rather, have associated the training schools of all top-level professions with universities. Thus has appeared the comprehensive university which, as I remarked a few minutes ago, is uniquely American.

I might at this point quit talking about the complex structuring of American higher education and proceed to the final question of why American colleges and universities do what they do, but just a little needs to be said about how we have organized our top-level educational institutions for purposes of control. On this topic I'm in the process of writing a book to be entitled *American Academic Government*. I'm therefore deeply engrossed in it, but I'll try to be brief.

As everyone connected professionally with an American college or university knows, they operate under the control of groups of laymen typically called boards of trustees. This system of control has been frequently denounced by professors who believe that our colleges and universities are, as a recent professor of a western state university recently wrote, "the most undemocratic in the world." He and those who think as he does believe that faculties and not outside laymen should manage our higher educational institutions.

The most common argument used by

these critics of lay control is that in European universities professors run things without the interference of outsiders and that if the great universities of Europe function that way, then we ought to follow their example. Some of these critics go so far as to assert that the board of trustees is an American adaptation of the business corporation's board of directors and that that's intolerable. I've spent a good deal of time investigating the history of the trustee concept, and I'm sure that these critics have no historical ground on which to stand since we adopted the idea of boards of trustees from the Scottish universities which got it from the Dutch, which borrowed it from the Swiss, which copied it from the Italian universities, which initiated it in the fifteenth and sixteenth centuries.

Further, in my judgment at least, it's most fortunate that we have lay trustees since the history of universities which have been entirely controlled by professors (Oxford and Cambridge, for example) leaves little doubt that universities –like all other social institutions–need both public checks on their affairs and the public understanding that comes from the participation of laymen in their management. That there have been and are limitations in and abuses of the lay board system, no one can deny; but the growth in wealth, freedom, and influence in the national life of colleges and universities can be credited in part, I have no doubt at all, to the trustee system.

Even those who disagree with me about the desirability of trustees will in all likelihood agree that those associated with colleges and universities–including engineering educators–ought to know how they are organized, how they are structured in size, function, control, and in other important ways. It seems axiomatic to me that if you plan to manage anything you ought to know how it's designed and how it operates.

Why They Do

This brings me to the fourth and final question: *why* do colleges and universities do what they do?

The most obvious answer is that those who organized them originally and those now in control of them determine their policies and that these policies enunciate not only methods of procedure but also the reasons behind the methods. This is a tenable answer, but it seems to me that the question needs to be discussed with the concept of enculturation in mind. This means that the question takes a new form and reads "why do colleges and universities enculturate the way they do?"

This revised question can be variously answered, but the most basic answer seems to me to relate to the reason *societies* (nations and major groups within nations like churches) enculturate. Why does Russia, for example, educate young Russians to be Russians; and why does the United States educate young Americans to be Americans. The obvious answer, I submit, is that a nation educates the way it does for two basic reasons: first, to ensure its survival, and second, to perpetuate and advance its way of life, that is, its culture. Sputnik has made Americans aware of these basic reasons for education, and we can all hope that the awareness has not come too late.

Not only nations but also other groups enculturate for the same reasons, and church-controlled colleges and universities in particular witness the fact. Instead of enlarging upon this point, however, let me move on from general enculturation to special enculturation and, specifically, to the special enculturation of prospective engineers as engineers. The question at issue, then, becomes "why do engineering educators enculturate the way they do?"

The same two answers, I suggest, apply here too: engineering educators enculturate intending engineers because they want their profession, first, to survive, and second, to advance in depth of knowledge and in quality of service to society.

This answer immediately raises a number of insistent questions including a long series of "hows." How to give students of engineering the kinds of knowledge and skills they need now and also years and years from now? How to decide how much general enculturation

an engineer ought to have? How to help him get it, a question which involves the hardy perennial of how much general education and of what kind should be included in the engineering curriculum? How much research should a professor of engineering do since the profession must not only disseminate present knowledge but also add to its quantity?

The list of "how" questions could be extended for pages, but I've named enough of them to observe that everyone of them involves differences of opinion and some of them intense conflict of opinion. Consider, for example, the last of the questions just cited—the proportions of a professor's time that should be given to teaching and research. This question seems to me to be the most complex and also the most vigorously debated of all those that engage the attention of people in higher education. It also seems to me to be the most urgent of all the problems confronting colleges and universities, the problem that must be solved before we can even begin to approach a sound plan for meeting the educational and research problems of our age. Engineering educators—like all others—should be interested in knowledge about divergent points of view on the issue.

My topic has been "Understanding the Academic World." I've briefly sketched some of the high points of the basic course I teach at Stanford. It carries the title, "An Introduction to American Higher Education." I've given an introduction to that introduction, and I hope that it has whetted your appetities for more from others concerned with the business of understanding what colleges and universities do, why, and how.

MATERIALS RESEARCH PROGRAMS

A 4.4. million dollar research program in materials science has been announced by the University of Pennsylvania. The research program, to be conducted for the Advanced Research Projects Agency (ARPA) of the Department of Defense, will be concerned with experimental and theoretical solid state physics, structural chemistry, inorganic chemistry, ceramics and all phases of metallurgy.

Included also are the electrical engineering of solid state devices and those studies in chemical engineering involving metals separation processes, high temperature kinetics, and corrosion.

While the initial contract covers only a four-year period, it is expected that the program will continue for at least ten years.

Other ARPA contracts have been awarded to Northwestern and Cornell Universities. In the first four years of their contracts Northwestern will receive 3.4 million dollars, and Cornell will receive 6.1 million dollars.

Educational Literature Displayed at Conference on Development of Young Engineering Faculties

An annotated list prepared by
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At the Conference on the Development of Young Engineering Faculties sponsored by ASEE Committee on the Development of Engineering Faculties in Cleveland on November 19–21, 1959, a display of various types of literature relevant to the theme of the Conference was arranged by the Committee. At the request of the attendees, the following annotated list of the material was prepared. Because of the interest in the list on the part of the conferees, it was decided that it should be published with the first of the series of papers resulting from the Conference.

The list is certainly not exhaustive. Its composition was dictated by the availability of the material on short notice to be assembled to serve as a display *representative* of literature in the field.

For convenience, the material has been divided into nine categories. In some of the categories, one or more of the items are marked with an asterisk to denote special value.

A. Short booklets, manuals, and pamphlets intended for the beginning teacher, most of them directed specifically toward engineering teaching.

* 1. *You and Your Students*, Office of Publications, Massachusetts Institute of Technology, Cambridge 39, Massachusetts. A 46-page manual on teaching prepared by a Faculty Committee of the Massachusetts Institute of Technology; contains bibliography. Also available from ASEE.

2. *Effective Teaching—A Manual for Engineering Instructors*, Fred C. Morris. New York: McGraw-Hill Book Company, Inc., 1950. Prepared by the Committee on Teaching Manual of the American Society for Engineering Education; 86 pages, contains bibliography.

3. *Instruction Manual*, Department of Public Relations, Georgia Institute of Technology, Atlanta, Georgia. A 48-page manual intended to be an aid to effective instruction; prepared by a committee at Georgia Tech; bibliography.

4. *Improvement of Engineering Teaching*, Report of the Committee on Improvement of Teaching, American Society for Engineering Education, University of Illinois, Urbana, Illinois, 1952. Final Report of ASEE Committee on Improvement of Teaching; 14 pages.

5. *Teaching Tips—A Guide-Book for the Beginning College Teacher*, Wilbert J. McKeachie. Ann Arbor: The George Wahr Publishing Company, 1956. Author states the publication is "a compilation of useful (occasionally mechanical) tricks of the trade" which have been found useful in running classes; 124 page manual.

* 6. *Bulletins on Classroom Testing*, John E. Stecklein. Bureau of Institutional Research, University of Minnesota, Minneapolis, Minnesota. A series of bulletins (presently extended to nine) written to

aid college teachers in constructing valid and reliable tests for classroom use.

B. Periodicals containing material directed principally to teachers and problems encountered by teachers.

* 1. *Journal of Engineering Education*, American Society for Engineering Education, University of Illinois, Urbana, Illinois. Published monthly (October through June); contains articles on all aspects of engineering education.

2. *Improving College and University Teaching*, 10 Commerce Hall, Oregon State College, Corvallis, Oregon. A national quarterly journal featuring articles on college teaching written by college teachers.

3. *Faculty Newsletter*, S. F. Borg (editor). Committee on Improvement of Teaching, Stevens Institute of Technology, Hoboken, N. J. A monthly newsletter circulated to all faculty members at Stevens Institute of Technology; presents quotations and excerpts dealing with good teaching drawn from a wide variety of sources.

4. *AAUP Bulletin*, 1785 Massachusetts Avenue, N.W., Washington 6, D. C. Quarterly publication of the American Association of University Professors; articles by college and university teachers on academic matters of both current and long range interest.

C. Books intended principally for teachers; some are general and inspirational in tone, others are more specific and are intended as textbooks for courses or seminars on college teaching.

* 1. *The Art of Teaching*, Gilbert Highet. New York: Alfred A. Knopf, Inc., 1950. The author, a Professor of Latin Language and Literature, considers the qualities which make up a good teacher, his methods, great teachers of the past, and teachers in everyday life.

2. *The Background for College Teaching*, Luella Cole. New York: Farrar and Rinehart, Inc., 1940. Twenty-five chapters dealing with aspects of higher education which should be of interest to a college teacher; contains numerous references permitting more specialized reading.

3. *College Teaching*, Paul Klapper. New York: World Book Company, 1920. Twenty-eight chapters devoted principally to teaching in various disciplines; one chapter on "The Teaching of Engineering Subjects," interesting because it was written four decades ago (chapter contains bibliography).

4. *College Teaching: A Psychologist's View*, Claude E. Buxton. New York: Harcourt, Brace and Co., 1956. Fourteen chapters devoted not only to a discussion of various teaching methods but also to a discussion of student evaluation, understanding higher education, etc.

5. *College Teaching and College Learning—A Plea for Improvement*, Ordway Tead. New Haven: Yale University Press, 1949. Based on lectures given by author for the Frank Ellsworth Spaulding Lectureship in Education at Yale University, 1947–8.

6. *College Teaching: Its Practice and Its Potential*, Joseph Justman and Walter H. Mais. New York: Harper and Brothers, 1956. Authors aim to help the college teacher "toward a better vision and accomplishment of his professional undertaking"; book "represents a considered mean between a discussion of educational principles and a compendium of specific practices."

7. *Essays in Teaching*, Harold Taylor (editor). New York: Harper and Brothers Publishers, 1950. Individual chapters by faculty members from different disciplines indicating in each case what is believed important in each area and how to go about teaching it.

8. *Great Teachers*, Houston Peterson (editor). New Brunswick: Rutgers University Press, 1946. A collection, from other sources, of twenty-two tributes to great teachers of the past written by their former students.

9. *A Handbook for College Teachers*, Bernice B. Cronkhite (editor).

Cambridge: Harvard University Press, 1951. Series of 18 separately-authored chapters based on lectures for an extracurricular evening course for graduate students at Harvard and Radcliffe.

10. *Higher Education in Transition*, John S. Brubacher and Willis Rudy. New York: Harper and Brothers Publishers, 1958. A history of American higher education, 1636–1956; numerous source references.
11. *Teacher in America*, Jacques Barzun. Boston: Little Brown and Company, 1945. Discussion of concrete educational questions in somewhat autobiographical manner; attempts to arrive at reasonable and practical answers.
* 12. *Two Sides to a Teacher's Desk*, Max S. Marshall. New York: The Macmillan Company, 1951. The author, a Professor of Microbiology, dedicates his common sense discussion of many aspects of teaching to "students, teachers, and bystanders."

D. Types of source material available for faculty members having the responsibility to design and conduct seminars, institutes, or workshops for engineering teachers; examples of courses and workshops in other areas.

1. *Study Guides* (Effective College Teaching; Higher Education in the United States), Ruth E. Eckert. College of Education, University of Minnesota, Minneapolis, Minnesota. Study guides for two of the courses in the area of higher education at the University of Minnesota.
2. *College and University Teaching Workshop*, 109 Commerce Hall, Oregon State College, Corvallis, Oregon. Reports of the annual two-week summer workshops on College and University Teaching held at Oregon State College since 1956.
3. *Academic Instructor Course* (Curriculum; Volume I–Principles and Methods of Instruction in the Air Force; Volume II–Evaluation in Air Force Instruction), Air Command and Staff College, Air University, Maxwell Air Force Base, Alabama. Some of the materials used in the training of Air Force instructors.
4. *Instructor Training Course* (Program of Instruction; Student Manual; Instructor's Manual), Instructional Methods Branch, Training Division, U. S. Army Engineer School, Fort Belvoir, Virginia. Materials used to train instructors in the Army Engineer School.

E. Another category of literature particularly useful to faculty members with working-level responsibility for faculty development, also of interest to administrators responsible for general policy: various reports of conferences, studies, etc. in the area of college faculty development.

* 1. *The Education of College Teachers*, Carnegie Foundation for the Advancement of Teaching, 1957–58 Annual Report, 589 Fifth Avenue, New York 17, N. Y. Summary of a discussion of the topic by the trustees of the Carnegie Foundation for the advancement of teaching; available separate from annual report.
* 2. *The Preparation of College Teachers*, Theodore C. Blegen and Russell M. Cooper (editors). American Council on Education, 1785 Massachusetts Avenue, N.W., Washington 6, D. C., 1950. Report of a national conference on the subject sponsored by the American Council on Education and the U. S. Office of Education.
3. *Graduate Study for Future College Teachers*, Joseph Axelrod (editor). American Council on Education, 1785 Massachusetts Avenue, N.W., Washington 6, D. C., 1959. Report of the Conference on College Teaching Preparation Programs sponsored in spring, 1958 by the Committee on College Teaching of the American Council on Education.
4. *Toward Improving Ph.D. Programs*, Ernest V. Hollis. Washington: American Council on Education, 1945. A study by ACE Commission on Teacher Education of

relation between graduate study and preparation for college teaching.

5. *The Graduate School Today and Tomorrow*, F. W. Strothmann. Fund for the Advancement of Education, 655 Madison Avenue, New York 21, N. Y. A 42-page booklet, prepared by the Committee of Fifteen, discussing the role of the graduate school in preparing scholar-teachers.
6. *Provisions of Professional Education for College Teachers*, Harold M. Byram. New York: Teachers College, Columbia University, 1933. A dissertation which studied the character and influence of education courses available to and taken by college teachers; also studied ways of improving such courses.
7. *Toward Better College Teaching*, Fred J. Kelly. Bulletin 1950, No. 13, U. S. Office of Education, Washington 25, D. C. Report based on studies of practices related to improved preparation of teachers by graduate schools and practices of undergraduate colleges employing teachers.
8. *Improving College Instruction*, Fred J. Kelly (editor). American Council on Education, 1785 Massachusetts Avenue, N.W., Washington 6, D. C., 1951. Report of a national conference on the subject sponsored by the American Council on Education and U. S. Office of Education.
9. *The Appraisal of Teaching in Large Universities*, Conference Department, The University of Michigan Extension Service, 1610 Washtenaw, Ann Arbor, Michigan. Report of a conference on the subject held in October, 1958.

F. General periodical literature principally dealing with higher education, occasionally contains material on faculty development; of some value to the mature teacher with a lively interest in a variety of educational problems; of even greater value to administrators and those who wrestle with these problems.

1. *Higher Education*, Higher Education Division, U. S. Department of Health, Education, and Welfare, Washington 25, D. C. Published monthly (September through May) by Higher Education Division of U. S. Office of Education; news, reports, and articles of general interest to higher education.
2. *The Educational Record*, American Council on Education, 1785 Massachusetts Avenue, N.W., Washington 6, D. C. Quarterly publication of the American Council on Education; articles dealing principally with topics of interest to higher education.
3. *Current Issues in Higher Education*, Association for Higher Edution, 1201 Sixteenth Street, N.W., Washington 6, D. C. Annual proceedings of Conference on Higher Education; usually contains papers and reports on faculty development.
4. *The Journal of Higher Education*, The Ohio State University Press, Columbus 10, Ohio. Published monthly (October through June); articles, editorials, and book reviews relevant to higher education.
5. *Higher Education and National Affairs*, American Council on Education, 1785 Massachusetts Ave., N.W., Washington 6, D. C. A bulletin of the American Council on Education, published frequently but irregularly; devoted to higher education topics of national interest, follows activities of legislative and executive branches of national government very closely.
6. *College and University Bulletin*, Association for Higher Education, National Education Association, 1201 16th St., N.W., Washington 6, D. C. Goes to all members of the Association for Higher Education; deals with Association activities and general topics relevant to college and university teaching.

G. Periodicals which deal with general or specialized problems at all levels of education, including higher education.

1. *The Journal of Educational Psychology*, American Psychological Association, 1333 Sixteenth St., N.W., Washington 6, D. C. Bi-

monthly publication of the American Psychological Association; publishes original investigations of problems of learning, teaching, and the psychological development of the individual; deals with all levels of education.

2. *The Journal of Educational Sociology*, Payne Educational Sociology Foundation, Inc., New York University, Washington Square, New York 3, N. Y. A monthly "magazine of theory and practice" in the area of educational sociology; deals with all levels of education.
3. *School and Society*, Society for the Advancement of Education, Inc., 1834 Broadway, New York 23, New York. Biweekly publication containing articles and news pertinent to all levels of education.
4. *School Life*, U. S. Department of Health, Education, and Welfare, Washington 25, D. C. Official journal of the entire U. S. Office of Education, hence contains material for all levels of education, higher education included.

H. Types of literature of special interest to those who undertake research on educational problems.

1. *Studies in Higher Education*, Division of Educational Reference, Purdue University, Lafayette, Indiana. Bulletins reporting the results of educational research by the Division of Educational Reference of Purdue University.
2. *Journal of Educational Research*, Dembar Publications, Inc., Box 737, Madison 3, Wisconsin. Published monthly (September through May); papers on educational research at all levels.
3. *NEA Research Bulletin*, Research Division of NEA, 1201 Sixteenth Street, Washington 6, D. C. Quarterly publication of the NEA; deals with NEA Research activities at all levels.
4. *Review of Educational Research*, American Educational Research Association, 1201 Sixteenth St., N.W., Washington 6, D. C. The Association, a department of the NEA, publishes 5 reviews a year, each devoted to a different area of educational research; vol. XXVI, No. 3, June 1958 devoted to "Teacher Personnel."
5. *Research Studies in Education—A Subject Index*, Phi Delta Kappa, Inc., Eighth Street and Union Avenue, Bloomington, Indiana. An annual compilation of doctoral dissertations completed, doctoral disserations under way, and a research methods bibliography.
6. *A Directory of Educational Research Agencies and Studies*, Phi Delta Kappa, Inc., Eighth and Union Streets, Bloomington, Indiana. Listing of educational research agencies within institutions of higher learning, educational associations, state departments of education, and large city school systems; indication of types of research carried on.

I. Annotated bibliographies and miscellaneous.

1. *College Teachers and College Teaching*, Walter C. Eels (compiler). Southern Regional Education Board, 881 Peachtree Street, N.E., Atlanta 9, Georgia (1957). An extensive and highly organized annotated bibliography on all aspects of college teachers and college teaching; with a recent supplement it covers the literature from about 1945; over 3,000 books and articles reviewed, classified, and cross-indexed.
2. *These Books Were Stimulating*, Delmer M. Goode. Office of Publications, Oregon State College, Corvallis, Oregon. An annotated bibliography of seventy books relevant in some way to college and university teaching.
3. *A Fact Book on Higher Education*, Office of Statistical Information and Research, American Council on Education, 1785 Massachusetts Avenue, N.W., Washington 6, D. C. A loose-leaf booklet (over 130 pages) presenting in tabular and graphical form the data on various aspects of higher education (enrollments, degrees, expenditures, etc.) over a period of years.

The Reconstruction of Mathematical Education

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Everyone is agreed that something ought to be done about mathematical education. Agreement ends at that point. In many ways the scene resembles the confusion of a political revolution. Prophets of all kinds abound, their confidence varying inversely as their knowledge. Disciples abound also; many people, particularly teachers, are aware of the limitations of their training, and are anxiously seeking advice and leadership. Many of us are in positions where our opinion is sought; we have considerable power to influence developments and a very great responsibility to do this wisely. The distressing fact is that *to reach a rational decision requires more knowledge than any individual can hope to acquire.*

It is clear then that some pooling of knowledge is required. But the process of pooling knowledge is no simple one. How, for instance, do you combine the insights into truth of Morris Kline, who regards physics as the main purpose of mathematics, with those of Max Beberman, who rejects explicitly and on principle any reference to physics in a high school mathematics course? Is there any objective procedure for doing such a thing? If not, we can hardly speak of making rational decisions. The whole question becomes one of subjective values.

This paper is concerned with the evidence that is available and the procedure that should be followed in making such decisions. Needless to say, I do not believe that this paper will produce an immediate reconciliation, with public rejoicing, between the followers of Morris Kline and the adherents of the Illinois program. Perhaps I can illustrate what can be expected by means of a particular illustration.

There is a well-known book by G. H. Hardy, *A Mathematician's Apology*. It praises mathematical research as the supreme way of living; mathematics is an art; the applications of mathematics are elementary and dull; those interested either in teaching or in technological uses of mathematics are second-rate minds and poor creatures generally, almost as low as newspaper proprietors and millionaires.

What are we to say of such an attitude? First of all, that for G. H. Hardy as an individual, it was inevitable and correct. To make a success of any profession, you have to feel that it offers the one satisfactory way of life, and that people who follow any other occupation are either to be despised as spineless or pitied as unfortunate. At any rate, you have to feel like this when you are young.

So long as Hardy's views are regarded as expressing his consciousness of the shape of his own soul, they are perfectly satisfactory. It is quite otherwise if they are regarded as a directive to society. Take his views on teaching, for example. Imagine two countries. In country A, the mathematicians despise teaching. In country B, a certain proportion of mathematicians try to inform young people of the beauty and fascination of mathematical work. This happened, for example, in Hungary. There can be no doubt which country would have better prospects of developing mathematically. Some kind of proportion would have to be observed; in the long run it would be harmful if the leading mathematicians spent all their time teaching, to the neglect of research. This type of argument

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seems to me perfectly objective, and capable of scientific proof or disproof. It is not concerned with values, but with the practical consequences of certain ways of acting.

There has been much talk of the importance of rigor and of stating one's axioms. I wish the idea of rigor could be brought into the discussions of mathematical education. Many declarations are based on some tremendous unconscious assumption or system of snob values. The range of validity of such statements becomes apparent once these hidden assumptions are brought into the light.

I might give an example of this. Lucienne Félix in her book, *The Modern Aspects of Mathematics*, quotes the following statement by Professor Dieudonné:

> "At the present time, the mathematics syllabus in our schools corresponds almost exactly to what was known in the year 1640."

This is a perfectly true statement. But what was Dieudonné's purpose in making it? I heard Dieudonné addressing an academic year institute. He advanced the following propositions: (1) Newman's anthology, *The World of Mathematics*,[1] omits all reference to recent mathematics; (2) modern mathematics has no contact with reality; (3) in the past physics provided problems for mathematicians to work on, but today we have plenty of problems in mathematics itself; (4) none of the really new mathematics of this century has found any practical application whatever; (5) it should be studied as an art form.

Clearly, Dieudonné's position has much in common with Hardy's. Hardy would not have agreed with the separation of mathematics from reality. Hardy regarded 5 being a prime number as a fact; it did not matter whether you liked it or not; there it was. But on the view of mathematics as an art practised for its own sake, he would certianly have supported Dieudonné. And that gives us the range of Dieudonné's remarks for teachers. If we have in our classes a student who wishes to become a pure mathematician like Hardy or Dieudonné—and both of these men did distinguished and significant work—the writings of Dieudonné and Hardy will help us to understand and advise such a student. But for a student who wishes, say, to compute the orbits of satellites, it is perfectly possible that the mathematics of the 17th century may be much more relevant than some branches of 20th century work.

I had better state my own values and axioms. It seems to me that all branches of mathematics, pure and applied, ancient and modern, concrete and abstract, are interesting and of value; for that matter, one could say the same of all branches of science and technology. My only regret is that life is too short for any one individual to master all these interrelated aspects of knowledge. The aim of scientific education, as I see it, is to produce workers in all departments of knowledge in their due proportions; to encourage communication between workers in different fields, and also between them and the general community; to raise the intellectual standards and intellectual interests of the whole country.

I would call an educational argument rigorous when it proves to a student that a certain mathematical discipline will enable him to do something which he himself needs or wants to do. A statement like, "We study sets because sets are a cornerstone of modern mathematics," is a completely unrigorous statement; it is about as bad as, "We study mathematics because it trains the mind." On the other hand, E. T. Bell's remark:

> "Any student who has plowed through a classical presentation of the theory of functions of a real variable before attacking some of the same material by the abstract method will grant that the strain on the memory is greatly reduced, and that insight is correspondingly increased." [2]

This sentence *is* rigorous; it indicates a definite topic—functions of a real variable—in which the abstract approach of-

[1] James R. Newman, ed., *The World of Mathematics*. New York, 1956.

[2] *The Development of Mathematics*, 2nd edition, New York, 1945, p. 508.

fers advantages. It would have been even more valuable if it had given specific references, in which one could compare the older and the more recent proofs of particular theorems.

I wish the advocates of modern mathematics would publish such lists of references, so that one could judge from specific instances the uses that are being made of modern abstract theories in scientific and technological applications. It would also be most useful to have some indications of the *number of people* who require to use mathematics in such ways. It is quite clear that someone who is doing research work at a really advanced level—the unification of relativity and quantum theory, for example—needs to know *everything;* there is no saying where one might not pick up a hint for such an investigation. The list should emphasize mathematics that is being used widely. Such a list would constitute definite evidence, instead of vague talk.

I should have liked to develop this section of my report much further, but I have not had leisure to do the work involved. Far less, of course, has anyone who is actively engaged in full-time teaching the leisure to make such an investigation. For those outside industry and science, what happens inside is largely a matter of fantasy. It would be most valuable if, from time to time, a summary of trends in the use of mathematics could be made available to teachers of mathematics. At what level should such a list be communicated? In the first instance, it should be made available to college professors, in particular those who are concerned with academic institutes and summer schools. This would allow the report to be concise, technical and detailed. A summary of this report, in slightly less technical terms, might also be communicated to high school teachers. I imagine the *Mathematical Monthly* and the *Mathematics Teacher* would welcome such material.

Does Modern Mathematics Supersede Classical?

Cars and trucks have superseded horses and carts, bulldozers have superseded picks and shovels. It is natural that laymen should believe that an analogy holds, that 20th Century mathematics makes earlier mathematics outmoded and superfluous. This impression is widespread; however, it is not difficult to find the relevant evidence. One can state quite definitely: the impression is false.

In the great bulk of technical and scientific papers, some modern concept is embodied in a paper that is predominantly classical.

A well-known report is F. J. Weyl, "A Survey of Training and Research in Applied Mathematics in the United States" (SIAM, 1956). In this report, Weyl several times refers to the *Symposium on Special Topics in Applied Mathematics.*[3] Weyl was evidently anxious to show American mathematicians that interesting mathematics could arise in applied work, so we may presume that the papers quoted contain as large a proportion as possible of modern mathematics. What then is the composition of these papers?

Leray applies topological considerations to the linear and non-linear differential equations for incompressible viscous flow. The paper by Garabedian, McLeod, Vitousek, seems entirely classical; it studies hydrodynamic questions with the help of geometrical function theory, conformal representation, partial differential equations and the hypergeometric function. A. H. Taub investigates singularities on shock waves by means of differential geometry, calculus, dynamics and numerical computation. Montroll's paper on the vibrations of a crystal begins, as one would expect, with differential equations and classical analysis; at a certain stage it draws on topology, namely Marston Morse's theory of critical points. A paper by Chandrasekhar on hydrodynamic and hydromagnetic stability is entirely classical. A series of short reports by McKac on signal and noise problems has references to stochastic processes and decision theory, but also to integral equations and Fourier series. Cairn's paper

[3] Published as Slaught paper in *American Mathematical Monthly*, Vol. 61, No. 7, Aug.–Sept. 1954.

on computational attacks discusses finite projective planes, matrices and Latin squares.

The general impression given by these papers is that a problem is formulated in classical terms and is developed a certain way along classical lines; at a certain point—which may well be a vital one—some modern theory is brought in.

One paper forms a clear exception to this general rule: Muller, on Boolean algebras in electric circuit design. This seems to use only very elementary ideas about Boolean algebra and the geometry of the cube in 2^n dimensions. This exception may well be significant. I quote two remarks from the article, "Professional Mathematicians in Government and Industry."

Dr. Welmers (of Bell Aircraft Corporation): "With Boolean algebra it has become possible for a relatively unskilled person to pinpoint a specific area in a system in which trouble may be occurring" (p. 8).

Dr. Robinson (IBM): "It takes someone with pretty intensive training to formulate the model originally. To use these models in practical problems, one does not require that same background. The task is to see which of several existing mathematical models fit the business problem, and then implement this on a computing machine. This can be done, efficiently, by people with a bachelor's degree in mathematics."

These quotations suggest that a new area of mathematical activity has come into existence. One would not expect the use of computing in business to be dominated by partial differential equations in the same way as, say, electromagnetic theory. Here, truly, there may be scope for a person of limited mathematical background, but with a small stock of modern techniques. It is quite possible that the number of people so employed may become quite large.

The recent history of mathematical employment is the following: In the 1935 volume of the *American Mathematical Monthly* you will find an article, "The Unemployment Situation for Ph.D.'s in Mathematics." In 1941, you will find a very careful and competent report by Thornton Fry, leading to the conclusion that American industry can absorb about 10 mathematicians a year. Both these articles, in their own day, were realistic. If they sound strange today, it is largely because of the appearance of the computer. *Numerically*, then, those with a training in the elements of switching theory may loom quite large in the society of the future.

What about including Boolean algebra in the high school syllabus? Some people cry out in horror, it is too difficult! The relevant point is quite different. Elementary switching theory is extremely simple. I have seen Franz Hohn give an evening's talk, which sent 9th graders home feeling that they understood how to design an electronic computer, all very excited about this and pleased with themselves. It is an admirable piece of enrichment. I should guess that in any level from 5th grade up, one could convey the basic ideas of switching theory in about two hours. The real question is, "What do you do with the rest of the time?"

In the more advanced theory of switching systems, it also seems to be possible to find, so to speak, islands of theory, in which a few modern concepts form a self-contained subject. Roth and Wagner's paper on "Algebraic Topological Methods for the Synthesis of Switching Systems" [4] is an example of a paper independent of calculus and of traditional mathematics generally.

Whether such islands are eventually destined to swell into continents I cannot even guess. I suggested earlier that mathematicians engaged in industry might make some kind of annual report to mathematicians engaged in teaching. A list of such islands, their number, size and population, would be a useful item in such a report.

The computer-minded mathematicians usually emphasize that neat analytic solutions of problems are the exception rather than the rule. This is undoubtedly true. However, an interesting sidelight is thrown on it by a paper of Bellman,

[4] *IBM Journal of Research and Development*, Vol. 4, No. 4, October, 1959.

Cherry and Wing on shock waves.[5] It is well known that, in some circumstances, a computer will give a completely nonsensical answer if it is asked to solve an unsuitable type of differential equation. In this paper, a particular non-linear differential equation is known to have an exact analytic solution. This is used to test the reliability of the computing methods used for this type of problem.

Most of the papers in the *Quarterly of Applied Mathematics* seem essentially classical; at least this was the impression I gained from a superficial sampling. *The Journal of Mathematics and Mechanics*, on an equally superficial sampling, left me with the impression of being "classical plus Doob"—classical methods augmented by a study of Doob's *Stochastic Processes*. This book might be cited in support of my thesis that one must have both the old and the new. Quite as many students would find difficulty with this book because they had insufficient expertness with calculus manipulations as because they did not know what Borel sets were.

Classical and Modern Concepts Within Mathematics Itself

We have made a very limited sampling of the literature of applied mathematics. What is the situation in pure mathematics? Can one disregard classical mathematics and learn simply modern theories? Or do the two interpenetrate? Or is classical mathematics even in some sense a prerequisite for modern mathematics?

Bourbaki begins by saying that his works are self-contained, but that they are particularly intended for readers with knowledge of the essential parts of the differential and integral calculus. "The usefulness of certain considerations will not appear to the reader unless he already has quite extensive knowledge, or unless he has the patience required to suspend judgment until he has an opportunity to see how these ideas are used." Bourbaki, incidentally, has a much better sense of the realities of teaching than the majority of people who attempt to imitate him.

Some samples from the Princeton Mathematical Series: [6]

Hermann Weyl, *The Classical Groups* (1946). I can hardly quote Hermann Weyl as a witness, since he himself expresses distrust of the whole tendency of modern mathematics. The book abounds in references to the works of mathematicians in past centuries.

L. S. Pontrjagin, *Topological Groups* (1946). Pontrjagin says the book is intended for those with "knowledge of quite elementary mathematical material such as analytic geometry, theory of matrices, theory of ordinary differential equations, etc." A knowledge of integral equations and partial differential equations is also a help, for Chapters 4 and 9.

Solomon Lefschetz, *Introduction to Topology* (1949). Lefschetz, in the first 20 pages, motivates the study of topology through reference to its historical origins —celestial mechanics, the Riemann surface, vector fields, gradient, divergence, curl, curvilinear integrals, complex variables.

The three men just quoted all show some sense of historical continuity, of modern mathematics as the crowning stage of a long process. I find no indication of this in the next work I cite, so the evidence is all the more striking.

Claude Chevalley, *Theory of Lie Groups* (1946). This, of course, is a subject for advanced research, enjoying considerable prestige. The editors remark that this book "is the first treatise in which a modern point of view has been adopted systematically." The list below gives the mathematical terms used in the first 7 pages. The author does not explain these terms; he assumes the reader knows all about them. This knowledge is therefore a prerequisite for reading the book; and the book itself is one that any student intending to become a research mathematician would certainly want to read. I have indicated in a very rough

[5] "A Note on the Numerical Integration of a Class of Non-Linear Hyperbolic Equations," *Quarterly of Applied Mathematics*, Vol. 16, No. 2, July, 1958, pp. 181–183.

[6] Princeton, New Jersey: Princeton University Press.

way the approximate dates at which the various concepts entered mathematics, and divided them, rather arbitrarily, into Classical, Transitional and Recent.

CLASSICAL: Cartesian coordinates (1620); Complex numbers (1572); Determinant (1693); Orthogonal; Continuous function; Upper bound; Exponential series (17th Century); Convergence (1676); Uniform convergence (1847); Characteristic roots of a matrix (1840 or earlier); Matrices (explicitly, 1855); Combinations (1653); Factorial; Integral analytic function (? 1835); Maclaurin expansion (1742); Jacobian (? 1835) Implicit function; Euclidean geometry.

TRANSITIONAL: Vector space (? 1840); Transform $S \times S^{-1}$ (? 1770); Group (1770).

RECENT: Emdomorphism; Topological space; Homeomorphism; Neighborhood.

The evidence above has been collected in a short time from a fairly narrow range of sources. Even so, it does suggest rather strongly that some previous contact with classical mathematics is an advantage rather than a hindrance in learning modern theories.

If this conclusion is accepted, a certain practical moral can be drawn. It is not proposed that the whole of mathematics should be taught in high school. Something has to be left for the college professors to teach. A division of labor between colleges and high schools has to be made. Would not the most rational basis for such a division be that high school teachers should try to improve their knowledge of those branches of mathematics *which lie nearest to what they already know*? Surely these are the branches which the teachers could learn most quickly and with the minimum of dislocation.

Advanced Research and Elementary Exposition

The mathematical crisis found our society divided into three water-tight compartments: those who discovered mathematics; those who applied mathematics; those who taught mathematics. The subsequent developments have been a series of gigantic oscillations as the three bodies began to interact.

Each section, naturally, threw into the pool the ideas it already had. The mathematicians had arrived at the following viewpoint: Mathematics deals with abstractions. It discusses objects, but says nothing about the nature of those objects, and one is certainly not expected to visualize those objects. One knows nothing about them, except a series of statements called axioms. One also chooses a logic, which is a series of rules for forming new statements. The subject develops by applying these rules to the original axioms. In particular, by starting from the concept "set" one could derive the whole of mathematics in this rigorous way. We do not even have to assume the idea of "number," since it is possible to construct the numbers from the original concept of set. And *set* itself here is, of course, not anything to be visualized, but simply an object satisfying certain axioms.

Some mathematicians felt this viewpoint to be of great value. They felt sure they could explain it to teachers quite quickly in summer institutes and that in no time the high schools would be full of teachers who thought like research mathematicians. It does not seem to have worked out quite like that.

Of course, this is a somewhat simplified account of what happened. Some mathematicians were also very fine teachers and understood the problems of high school teachers. But in general, the problem of establishing communication was not an easy one. Consider, for example, the following quotations:

Professor Philip Jones on "The Mathematics Teacher's Dilemma":

"A considerable number of our best and most conscientious teachers have become disquieted, uncertain of themselves and even frustrated to the point of wondering whether they should seek early retirement. . . . Having heard such terms as Boolean algebra, the algebra of sets and modern algebra mentioned in the same context with 'modern mathematics,' some teachers have leaped to the conclusion that the fundamental operations with real and complex numbers and the solution of linear and quadratic equa-

tions, if not to be dropped, at least are to take a definitely subordinate position. . . ." [7]

Professor Van Engen reported in *The Mathematics Teacher,* April, 1960, p. 301:

"When, as in some instances, institute programs frighten, frustrate and fail many teachers, the Council should be genuinely concerned."

This kind of confusion is almost inevitable when a body of people move into an undertaking of which they had no previous experience. It is extremely encouraging to note that the mathematicians are learning from experience. A recent conference, called for the benefit of mathematicians who are to teach summer institutes, stressed very strongly these dangers. Mathematicians must not simply hand out their own ideas in the way they have become accustomed to; they must study what their students know, and try to build on that.

The first unsuccessful approach of the mathematicians was supported by a kind of theory that advanced mathematics had a great contribution to make to elementary exposition. For the latest ideas in mathematics are very clear and sharp; surely it should be easier to teach clear ideas than vague and muddled ones. This view was sometimes expressed, "If it is good mathematics, it will be good pedagogy." This sounds very plausible; there may even be a half-truth in it somewhere. If so, people must be using the wrong half. It is rather like saying that the music that appeals to an experienced musician should make a good nursery rhyme. This can happen, but the reverse is probably much nearer to being the general rule.

Madame Félix, in her book, *The Modern Aspect of Mathematics,* goes further than I would in linking Bourbaki and elementary instruction. But she at least envisages the possibility of a moderate position:

"Even if we decide to preserve the traditional order when the student first learns the subject, we can call his attention to those things which will help him to understand it and which will allow the student *later on* to conceive the possibility of a unifying axiomatization."

This, if I understand it correctly, means that teachers should be aware of the work their students will do later at college, and should so teach that the students will find it easy to follow the college presentation. With this, I imagine, no one would quarrel.

I should like to quote the views of a leading research mathematician on the nature of proof, as this provides an interesting contrast:

"No matter if we do use, frequently, questionable methods of proof, we are usually gathering mathematical fruit. That the calculus of Newton and Leibnitz had virtually no basis at all from the viewpoint of modern standards did not invalidate the calculus as mathematics. All it needed was bolstering up. . . . No one suggests that we turn the calculus out of our mathematical libraries, for we recognize *intuitively* that it is a body of acceptable mathematics—still susceptible to improvement, perhaps. . . . To put the matter bluntly, it is a case of our *knowing mathematics when we see it.* And we don't set out to prove a theorem in the first place unless we think it is worth proving. . . . And this brings me to a consideration of the source of the thing we set out to prove—our theorem. Where do we get it? I think most of us would say, from our intuition." [8]

Here, while the existence of modern standards or rigor is clearly recognized, the stress is not on these at all, but rather on intuition, the process by which we arrive at discoveries. The successful institutes, so far as I can judge, were those which showed not merely the results of mathematics, but how mathematicians arrived at those results. Not rigor, not modern methods and results, but intuition was the vital element in instruction.

The importance of intuition has been stressed by several mathematicians who are good teachers—Professor Polya and Professor Tucker, for example—but it is still insufficiently recognized by mathematicians. At the Philadelphia Conference of the Mathematical Association,

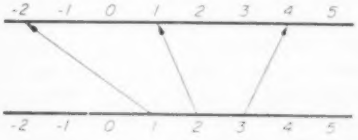
[7] *University of Michigan Bulletin,* January, 1959.

[8] R. L. Wilder, "The Nature of Mathematical Proof," *American Mathematical Monthly,* Vol. 51, 1944, p. 317.

Professor Kemeny criticized the definition of a function as "a set of ordered pairs"—this has been one of the most popular Bourbaki for Grade 9 items—on the grounds that it made no appeal to intuition. Some great mathematicians, Professor Kemeny said, had been completely lacking in a sense of logic; no one, however, could be a great mathematician without intuition. Professor Kemeny suggested that the idea of *mapping* (also taken from higher mathematics) gave a much more vivid image of "function."

Needless to say, it is perfectly legitimate to draw on higher mathematics, if one obtains a vivid method of teaching by so doing. But the test lies in the teaching, not in the nobility of the original source.

Professor David Page, in his work with 6th grade, uses a diagram very close to the idea of mapping mentioned above. He has two lines, the "starting line" and the "landing line." Arrows are drawn from one to the other. When studying the function defined by $f(x) = 3x - 5$, arrows are drawn from each number x on the starting line to the corresponding value $3x - 5$ on the landing line. Special attention is given to "stand-still points," i.e., those points for which $f(x)$ is equal to x. The diagram is one that



directly illustrates the concept of mapping (though the word mapping is never mentioned), and one senses that fixed point theorems in topology may have suggested the interest in "stand-still points." But the whole thing stands up by itself as a teaching device. It prepares students for advanced ideas without mentioning advanced ideas. The students, in fact, made discoveries in elementary algebra with the help of this device. But one could very well pick up the same type of diagram in teaching calculus. On the starting line one could write expressions such as x^2, x^3, x^4 and on the landing line their derivatives $2x$, $3x^2$, $4x^3$. The arrow would go from the expression to its derivative. The search for a stand-still point would lead to the exponential e^x, an expression which is equal to its derivative.

In the teaching of calculus, many professors are afraid above everything that their treatment may not be rigorous. But a much more serious fault is that it may not be intuitive. I had the following experience with teachers, all of whom had done well in college calculus classes. They were shown the expression

$$\int_{x=0}^{x=t} (e^{-x^2} + 4 + \sin^2 x)^2 \, dx$$

(It is given that t is positive.) First they were asked whether this integral defined a function of x and t or of only one of these, and it was eventually agreed that it gave a function of t alone. What kind of function of t then—increasing, decreasing, oscillating, constant, or what? There was great difficulty with this question. This question was also shown to a student who was getting straight A's in a college calculus course. He spent an hour on it (trying to evaluate the integral!) and failed to find an answer.

Now the answer to this particular question is intuitively evident in a matter of seconds. This integral would arise in trying to find a certain area below a curve, which one can sketch. All that matters about the curve is that it is always above the axis OX, since the integrand is positive. Clearly, then, the larger t is, the more area will be taken in; the area steadily increases with t; the integral thus defines a steadily increasing function of t.

It is truly remarkable that such simple ways of seeing results are rarely pointed out. Mathematicians seem to feel that they are confronted with a dichotomy—either a cookbook course, or a "rigorous course which shows what mathematics really is." The idea of a course showing the intuitive paths by which mathematicians are led to suspect results (results which, of course, have to be checked by rigorous proof at a later stage)—this idea seems to have occurred to very few peo-

ple, at any rate until recently. It is a most significant sign of present trends that the S.M.S.G. material embodies Professor Richmond's highly intuitive approach to calculus.

You may be interested in our experience at Wesleyan University. For some years we have been disturbed by the fact that large numbers of students come to college intending to major in mathematics, and after a year or so decided to change to some other subject. This happened for several years, at a time when the freshman course consisted of fairly conventional formal mathematics—constructing the rational numbers and the real numbers with great care, formal definitions of a limit, and so forth. Then an experimental syllabus was tried with the emphasis on set theory. This seemed to leave a mark in students' memories as one of the most lethal courses ever given. Recently, Professor Rosenbaum introduced some ideas which, for a Liberal Arts College, represent a very radical departure. It came from experiences such as the following:

A student had been attending a course on matrices, and doing just enough work to keep out of trouble. Later he left and took a post with I.B.M. As a result of this he sought Bob Rosenbaum out and said, "I do wish I had kept properly awake during your course on matrices. I am using matrices all the time in my work and I am having to study them for myself." This led to the thought, "Why wait until students have left college for them to discover that mathematics has some practical uses?" We have just started a scheme by which we invite anyone who has any kind of mathematical problem to submit it to us; problems may come from industry, from government, from economics or psychology, from the chemistry or physics department—from anywhere; teams of students and faculty study these problems and attempt to find solutions. It is too early to say what the eventual effect of this experiment will be, but it is already clear that the practical nature of the work has a great appeal, and is attracting many of the ablest students towards mathematics.

I might digress for a moment to make an appeal. This is a new departure that may be copied elsewhere and may prove very effective in increasing the supply of applied mathematicians. It should receive the support of engineers. In building up such a scheme, it is not too easy to organize a steady supply of problems sufficient to keep the students busy. Some industrial problems are urgent and cannot be left in abeyance while a team of undergraduates solves them. But industry also has chronic problems, things you hope somebody, some day, will investigate and sort out. We should very much appreciate it if any engineering or scientific firm can suggest problems which we might attack. Needless to say, we do not guarantee to solve them.

Wesleyan's solution to this problem may be, for a liberal arts college, unique; the problem itself is widespread. In most colleges of any standing, you find concern about student morale in mathematics. I quote, for example, the *Yale News* of February 23, 1960:

> "When a random sample of 400 undergraduates was queried concerning experiences with mathematics, the replies ranged from the unenthusiastic to the disgusted. One senior reported, 'I had intended to major in math, but after two years I changed to an American Studies major.'"

I hope Yale will forgive me for singling them out in this way. I choose Yale precisely because they are one of the best universities in the country. They have students of exceptionally high ability. They have professors who are outstanding in mathematical research. They bring these two elements together; the introductory courses are not left to graduate assistants nor to junior faculty. Surely then, if modern mathematics were the vitamin missing in our past diet, the professors at Yale would have been able to furnish it, the students at Yale would have been able to absorb it. If we find that Yale shows the same symptoms of mathematical vitamin deficiency that our colleges in general experience, we have the basis for a resounding *a fortiori* argument. The name of the missing vitamin is not "modern mathematics."

I claimed earlier that the way and the extent to which modern mathematics enters into industrial applications could, in principle, be determined with scientific objectivity. I would not claim that the considerations of this section could be tested objectively with anything like the same finality. But these considerations do show that one can doubt, on rational grounds, whether the key to improved elementary instruction is to be found in the intensive study of "modern mathematics."

What Is the Central Issue?

The main disservice, it seems to me, that the slogan of "modern mathematics" does is to distract our attention from the real nature of our problems. It suggests some new, imposing, glamorous cure, when in fact some quite humble and common-sense observations would meet the case better. It makes us search in the heavens for a solution that lies under our feet.

It astonished me very much, when I first came to America, to be asked to lecture to summer schools on Modern Higher Algebra, and find that many of the students had little or no knowledge of elementary algebra. It is rather a desperate situation when a teacher does not understand the actual subject he is teaching, and it seems a strange remedy to teach him something else. In summer schools I have had teachers who could not solve quadratic equations, and were somewhat shaky on linear ones, interrupt me because I said "number" when they thought I should have said "numeral." I developed a system for dealing with this: if a student held me up in this way, I would ask him to solve a quadratic equation.

You may think I am exaggerating, but one can produce documentary evidence of this state of affairs. Before I came to America at all, I studied the book on calculus produced by the C.U.P. The object of this was to expound modern ideas on the teaching of calculus. This was going along nicely when suddenly, on page 37, about a page was devoted to pointing out that when you are dealing with the fraction $b/(a+b)$, you cannot simply cancel the bs and write $1/a$. It seemed strange to teach calculus to students who had not mastered the very beginning of algebra.

This is not yet the root of the matter, but it is an important point to note. It seems quite exceptional to find either a student or a high school teacher who has real facility with algebra. In colleges throughout the country, thousands of hours must be wasted in calculus lectures while professors explain points in elementary algebra. Lack of elementary algebra is one of the main hindrances to communication of mathematics; if you try to explain any new idea, whether it is calculus, or matrices, or coordinate geometry, by algebraic examples, the students spend so much energy in coping with the mechanics of the algebra that they have no energy left for understanding the new concept.

Now here one reform calls out to be made. It is quite obvious that to have facility with algebra you must be continually using algebra. This does not mean mere repetitive drill, but rather that you should be continually applying the same old methods to new and interesting problems. What happens in fact is that a student learns algebra in grade 9, and is then given a year to forget it in grade 10 while geometry is learned. This is a fantastic arrangement. If one took existing texts and arranged for students to study algebra and geometry on alternate days, through grades 9 and 10, that would represent a tremendous advance. People tend to think this cannot be done, because of difficulties in administering the schools. To think so is to be quite blind to the power of the revolution in which we live. It is like someone in 1910 who thought that the development of cars would be limited by the state of the roads.*

* The way in which subjects are continually reviewed in English high schools may be seen from an inexpensive booklet, "Graded Tests in Higher School Mathematics," L. Malone (St. Martin's Press, New York). Each week the student is expected to work an examination paper; each paper contains questions involving geometry, algebra, trigonometry, coordinate geometry, solid geometry and calculus.

The package system here encourages a student to learn a subject, get his grade, and forget it. A typical answer to the question, "Do you know anything about this subject?" seems to be, "Yes, I did that and got a B+ but I can't remember anything about it." This is a rather insecure basis, particularly for the future teacher.

Napoleon held the view that in a battle many things had to happen, but that there was always one central, decisive task which was the key to success in all the rest. What is this decisive task in mathematical education here? It is the *abolition of rote learning*. It is extremely difficult to learn even arithmetic by rote; children who try to do so invariably quote a rule on the wrong occasion. It is impossible to learn any branch of higher mathematics by rote.

In all countries, of course, the poorer teachers believe that rote learning is the only safe way to success. In fact, it is infinitely harder to learn a subject by rote than to understand it. The problem in integral calculus that I quoted earlier is a good example of this. It is immediately solved by a student who sees what it means; it is virtually impossible for the rote learner.

A college professor faces the difficult situation that his students have had twelve years of conditioning to rote learning. To wean them from it is difficult; to surrender to it is fatal. One can spend more energy and get less results at college level than in any other department of teaching. Quite clearly, changes have to occur at the earlier levels if college teaching is to become anything but an extremely ineffective and frustrating procedure.

Even in high school it is hard to break rote learning. Students doing experimental teaching in high schools frequently report something like the following: "I tried to get the students to discover this result; they did not want to find it out or to know why it worked. They have always been told what to do; they expect you to tell them a rule. They get mad if you don't."

I have experimented with students of various ages, and the results are more or less as follows: I can sometimes get college students mildly interested in mathematics; I can get a few high school students interested; I can get a response of explosive enthusiasm from grades 5 and 6.

The situation in short is this: Children are born wanting to think and discover for themselves; rote teaching systematically destroys their powers of thought; the older the students are, the less curiosity and intelligent interest you can expect.

A Comparison with Overseas

This argument would suggest that the critical point lies somewhere in the elementary or junior high school. What we believe can be achieved is very closely connected with what we ourselves did at that age, and I should like to sketch the syllabus as I remember it in an English school of the 1920's. I would emphasize that this was not a school for the gifted; it was a good school, but in no sense a famous one. We had completed arithmetic by roughly 9 years of age. I am very grateful that I escaped the utter vacuum of grades 5 through 8 in this country. After arithmetic we began playing with geometrical instruments, then some actual deductive geometry. Algebra was added to this at 10 or 11 years of age—as I have mentioned already, we did not have the concept of "a year's algebra and then a year's geometry"; our schedules were based on the rhythm of the week, rather than the day, so that we could mix algebra and geometry, and later algebra, geometry and trigonometry, and so on. Trigonometry we started while still in this same school; I left when I was 13½ years old, and I know I had met the formula

$$\tan \tfrac{1}{2} A = \sqrt{(s-b)(s-c)/s(s-a)}$$

for the general triangle. One or two of us had a special liking for mathematics, and the principal coached us privately in the beginnings of calculus. We knew how to locate maxima and minima, and to find the area under the graph of a polynomial.

When I first came to America, I was most surprised to find the students always 3 or 4 years older than I expected them to be from the title of the subject matter.

I did not say too much about this, as it is rarely wise for one country simply to copy what another does. But it has gradually become clear to me, from a study of purely American evidence, that this question of age is highly significant.

First of all, there is no doubt that American children are just as intelligent as European ones. Among these children there are the same proportion of exceptionally gifted students as in Europe. In a math club I ran in Middletown High School, where we studied intuitive calculus, easily the best student was a 9th grader. In the 7th grade he had had extremely poor grades for mathematics—not because he could not do it, but because he did not think it was worth doing. This is a general phenomenon; in the later years of arithmetic, the abler students turn away from mathematics because they are so bored with infinite repetitions of the same, simple stuff.

Grades 5 through 8 seem to be the strategic point. Already in high school students are beginning to be too busy; they do not have the time or the mood to become interested in mathematics. In grades 5 through 8, on the other hand, they have time and they have a lively interest. I have been teaching algebra one hour a week to a grade 5 class. This is the best class of my week; I look forward to it because this is education as it should be—students who actually want to know something. This is an excellent time for students to form new interests. At college, students are married or thinking about becoming married—their interests naturally are practical; at high school, adolescence is already upon them; in grades 5 and 6, nature seems to have arranged things so that children take a wide, intelligent interest in life. Adolescence is still in the future; I notice with my grades 5 and 6 that when they work in groups, boys work with boys and girls with girls.

It is surely a tremendous pity to let these years go by and do practically nothing with them. If these years are left empty, if students are working two or three years behind their actual capacity, they naturally become bored, idle, troublesome or even delinquent.

One very disturbing thing I have noticed in elementary schools. Frequently students have no image at all of what they are talking about. They can multiply 3 by 4 or divide 21 by 7, but if you ask them, "How do you picture three fours?" or "In what circumstances would you be wanting to divide 21 by 7?" they have no answer. They do not picture these things; they go by rules. Somewhere, down in grade 1, they may have buttons or bars to represent numbers, but after that there comes a stage of many years where they are calculating without any image at all of what they are doing. It is not surprising that this almost destroys the capacity to reason. Already in grade 5 there is difficulty in getting children to *look* at a problem and reason from what they see, instead of remembering rules and results. If you destroy the children's vision at this stage, you will find it very hard to restore it later on.

An example of vision. There is an international delusion among students that $(x+y)^2$ is equal to x^2+y^2. This occurs even in the work of college students. In grade 6 we consider this in the following way. First the students are encouraged to picture multiplication by means of rectangles. They would picture three fours with the help of the following diagram:

. . . .
. . . .
. . . .

The square of a number is, of course, a particular case of this. Now we examine the question of whether $(x+y)^2$ is the same as x^2+y^2. We take a particular case, such as $x=2$, $y=3$. Is the square of $(2+3)$ the same number as the square of 2 added to the square of 3? Arithmetic shows that this is certainly incorrect. Can we amend the formula so as to make it true? We picture the square of 2 added to the square of 3 as follows:

. .
. .

. . .
. . .
. . .

Do these dots fill a square 5 by 5? Certainly not. What, then, should be added? The empty spaces have the form of rectangles. Each empty rectangle has the dimensions 2 by 3. So we need to add 2×3 twice to get the correct result. It is not hard for the class to discuss whether there is something special about the numbers 2 and 3, and whether this device would work of any two numbers x and y.

Rote learning represents a semi-feudal attitude. Miss Jones teaches what is in the book. I doubt if she ever speculates about how the material got into the book. Does she believe that people who write books belong to a superior class of human beings, that they understand things hidden from her eyes? Or does she think all the books are copied from one orginal book?

People reason about things with which they are familiar; they parrot opinions on things outside their own experience. If we are to get Miss Jones to see something for herself—and unless she does this, she will never encourage her students to see things for themselves—we must at all costs avoid frightening her.

The Illinois program very rightly stresses as one of its aims the abolition of rote learning; it stresses that students should make their own discoveries. If it made this clear—if this publicity presented the program as the discovery program, the anti-rote learning program—I would support Beberman enthusiastically. But this central theme has been confused by all kinds of frills, by an insistence on a special language, by stressing "modern mathematics." The result is that Miss Jones thinks her error lies in *what* she teaches, not in *how* she goes about it. She thinks she ought to teach sets, and she is terrified at the prospect.

Max Beberman, I think, brought sets in partly because, this being a new topic, it would be impossible for teachers to fall back on rules. They would have to teach by discovery. This line of thought has much that is sound in it, but it overlooked the paralyzing effect of unfamiliarity. One can use sets as discoverey material (as one can use anything else) but if so, it is essential to play them down; to emphasize that they represent quite a trivial aspect of every day experience; that there is nothing much to them. Then Miss Jones may venture to look at them.

But on the whole, it seems better to begin with ideas that Miss Jones already knows. If you look at my discussion of $(x + y)^2$ above, you will find that it uses the following ideas only: the numbers 2 and 3, addition and multiplication, the shapes of rectangles and squares. It uses, of course, the general idea of the algebraic symbols, x and y, but the meaning of these would have been discussed in earlier lessons, using extremely low-brow and commonplace approaches. Instead of going to Miss Jones and frightening her with the word "set," we begin with ideas already perfectly familiar to her, and point out some things she could do with these ideas that probably have not occurred to her.

One cannot expect Miss Jones to revolutionize her outlook overnight. One has to provide her with a steady stream of material, which she can introduce into her existing syllabus as enrichment. In the course of years she will enlarge her repertoire. All the time, the new material should be as close as possible to what she already knows. This is how revolutions are made: not by taking one big step, but by taking a lot of little steps quickly, one after the other.

I mentioned earlier the transformation of America by the automobile. This transformation was brought about, not by the cars built for kings and millionaires, imposing though these were. It was brought about by Henry Ford's Model T. The present transformation in mathematics has some resemblances to the coming of the cars. The great difference between 1960 and 1940 is the enormous increase in the *number* of mathematicians needed. We need not only the scientists and engineers and the mathematical specialists; we need teachers in high school and elementary school to train them. In effect, we have to make some kind of mathematical insight part of the general culture of the community. Many different programs will be needed to bring this about; among them I hope there will

be at least one that has the characteristics of the Model T.

You may wish for some details of the method of approach I outlined above. A report on algebra for grade 5 appeared in *The Arithmetic Teacher* for January 1960, page 25. For the last two years, *The Mathematics Student Journal* has followed the policy of using familiar traditional topics as a basis for experiment and discovery. The circulation of the journal has risen from 30,000 to 70,000 in this period. The most encouraging feature has been that high school and junior high school students have increasingly been sending in original observations and discoveries. The issue for May, 1960, consisted almost entirely of such student contributions. Later this year, Wesleyan School Services Department will be distributing a booklet called "Math Patterns in Science." This consists essentially of an introduction to algebra—which Miss Jones will be able to read without any difficulty—and some illustrations of the use of algebra in elementary science. This booklet will be distributed, in the first instance, to 7th grade students, but it could perfectly well be used to introduce algebra in grade 5. It is, in fact, based on my experience with grade 5.

Mathematics and Physics

A subject which must be in a very remarkable situation at present is high school physics. I should hate to write a high school physics text at the present moment. For in physics you continually have to appeal to an algebraic argument and, as we have noticed, a working familiarity with algebra is only found in very exceptional students and teachers.

A student who has a good background in algebra has a tremendous advantage in learning physics. Suppose, for example, he is right at the beginning of mechanics, and meets the formulas

$$s = ut + \tfrac{1}{2}at^2 \text{ and } v = u + at.$$

It is immediately clear to him that he could eliminate t between these two equations, and thus obtain *some* equation connecting a, s, u, v. His eye glances down the page and sure enough, there it is: $v^2 - u^2 = 2as$. He can derive this for himself in a few seconds. He hardly needs to read the intervening print.

I remember reading, in my first year at High School, two very nicely-written little books, *Statics* and *Dynamics*, both by R. C. Fawdry and published by Bell. It gave me a sense of importance to feel that I knew how to design a roof truss, though I suppose this is a thing one rarely needs to do. These books continually called for the use of elementary trigonometry, algebra and coordinate geometry. The coordinate geometry came, for example, in the formula for center of gravity. There would be problems in which one or two forces were unknown; these usually meant solving simultaneous equations. This continual interplay of mathematics and physics tended to strengthen one's grasp of both subjects. The physics helped to illustrate the mathematics, as well as the mathematics explaining the physics.

A thing I have noticed among college students here is that they tend to lack the idea of a condition *for* something, or an equation *for* something. For example, in a very elementary calculus course, we were investigating the maximum and minimum of a cubic curve. After reaching an equation such as $dy/dx = x^2 - 5x + 6$, it did not occur to the students that they could find where dy/dx was zero by solving the appropriate quadratic equation. They had learned to solve quadratics as an end in itself; it did not occur to them that a quadratic equation might arise in the course of an investigation.

Morris Kline, I think, has been quite right in emphasizing that the linking of mathematics and physics is *one* way of improving the teaching of mathematics. Most experiments in physics where one attempts to find a law—for example, the connection between the length of a pendulum and its period of swing—help to convey the concept of *functional relationship*, and in this way one can convey an intuitive picture of *function* to some students who would be left cold by the discussion of ordered pairs. In physics, too, a student continually has to form an

intuitive picture of an algebraic formula: the inverse square law portrays an interaction that becomes feebler as the distance increases; Hooke's Law, on the other hand, portrays a force that becomes fiercer and fiercer as distance increases.

One value of physics for mathematics is that the problem has to be formulated by the student himself. In the old-fashioned books on mechanics you would find problems about shelves performing simple harmonic motion vertically: a particle rests on the shelf; at what moment does it jump off? This may not be a very practical problem, but at least it forces the student to analyze the situation. He cannot even begin to make calculations until he has realized that, unless the particle is glued to the shelf, the reaction cannot become negative. Now this problem of analyzing an actual situation in mathematical terms is probably the hardest one an engineer has to face. He may learn quite easily to solve routine mathematical questions; but he goes into a factory, and he does not see any routine questions. He only sees machines. He has to extract the questions for himself.

In the discussion on professional mathematicians, already quoted, Dr. Gaskell and Dr. Welmers agreed, "That is the chief role of the industrial mathematician, the formulation of problems" (*SIAM Review*, January, 1960, page 5). At present, so far as I can see, we give students little or no practice in this all-important skill, the formulation of problems.

Coordinate Geometry and Matrices

There is one point on which I should like to ask Morris Kline whether he has had any second thoughts. The recommendation of the Commission on Mathematics stressing coordinate geometry seems to me the most sensible proposal yet made. I understand Morris Kline opposes this. This seems to me inconsistent with his general position. I noticed in Dr. Thornton Fry's report of 1941—that is to say, in the classical age before the computers—that Dr. Fry stressed the need for the engineer for "geometry, particularly of the coordinate variety," or words to that effect.

I remember Morris Kline giving a list of the subjects he considered useful—electromagnetic theory, hydrodynamics, etc. Now none of these can be tackled by means of synthetic geometry. Surely every branch of science developed since Newton calls for the analytic approach—coordinate geometry in excelsis.

Coordinate geometry is an exceedingly teachable subject. I have found it very popular in grades 5 and 6. They like it because it gives them something to see. It is very suitable for the discovery approach. The students learn very quickly to plot points. They can be shown the line joining (6,0) to (0,6), and asked to record the coordinates of points on it. They write down (6,0), (5,1), (4,2) etc. Then they are asked what they notice about these numbers. Among other things, they notice that the coordinates sum to 6. They write this in the language of algebra as $x + y = 6$. And that raises a whole series of further questions for enquiry: does the same sort of thing happen with other lines? This work also gives them a method for later experimental work, when they plot a series of experimental data, which lie nearly on a line, and thus reveal an underlying linear law.

A somewhat different point may be raised in this connection. Some programs have suggested that we over-emphasize "manipulation." If anyone is going to teach coordinate geometry, particularly by the discovery method, with students producing all kinds of problems and suggestions not in the book, he will find that he needs all the manipulative resourcefulness he can command. That is one reason why I support the Commission's proposal. But perhaps "manipulation" is an ambiguous word. I interpret it to mean the use of algebra with judgment and skill; other people may use it to mean the working of routine exercises on a single rule.

Coordinate geometry leads on very naturally to matrices, which are undoubtedly one of the central topics today. They occur in the recent developments of "finite mathematics"; they occur in clas-

sical work, when a differential equation is solved numerically as a difference equation; they arise in group representations, whether regarded as a branch of algebra or of quantum theory; they arise in many other connections.

This whole chain of subjects—elementary algebra, geometry, trigonometry, coordinate geometry, matrices—can all be presented to the student in a highly visual, concrete manner. The student will all the time know what he is doing, and be able to check his results for himself. If he starts in grade 5, he should still have several years left in high school for calculus and, if he likes, for modern abstract mathematics. I am speaking here primarily of the very ablest students, who want to do this. I should hate to see the others forced to do it. But even the average students are capable of, and would enjoy doing, far more exciting work than the obsolete commercial arithmetic they get at present.

Independent Student Reading

Everyone who has experimented in the schools agrees on one fact: the students absorb new ideas much more quickly than the teachers. There is nothing surprising about this; children are always more flexible than adults. The children of immigrants learn the language, while the parents may never master it.

One of the best things I remember about high school in England was the care taken to see that every student was allowed to work ahead at his own pace. Once you had established the fact that you were a mathematician, that you wanted to learn mathematics, you were given the green light and you went ahead, reading as fast as you could. I remember my last two years in high school, when we specialized in mathematics after eight years of general education—Latin, history, French, English, physics, chemistry, etc.—we spent 96 per cent of our time on mathematics. We were not taught for 24 hours a week. We read books for ourselves. I remember reading about half of Jean's *Electricity and Magnetism* at this time, as well as several books on differential equations.

I have ample evidence, as editor of *The Mathematics Student Journal*, that there are plenty of students in this country who could do the same. The ablest, the most enthusiastic students present the simplest problem. They need not absorb any teaching manpower at all. The only obstacle is a psychological one. A sadly over-organized educational system finds it hard to believe that some students, at least, can work without the assistance of a teacher. Colleges could help in this respect by making it clear that they would welcome students who have not spent four years sitting in required classes, but who have attained a level of mathematical knowledge, by independent study, far in excess of the standard four-year course.

Rote Learning the Central Issue

I would like to conclude by returning to lower ground, and emphasizing the real nature of our present age. There is a kind of historical continuity from the earliest times to the year 1945. This is the age of rote learning. Societies are stable; conditions change slowly; you study the tradition of the elders and live by it. Human beings perform mechanical tasks both physically and mentally. That age has ceased to exist. Nothing now stays fixed. The engineering you learn at college is out of date by the time you are fifty. The machine takes over everything that is mechanical. To quote Dr. Rosser on the particular question of computer coding: "There is considerable routine mechanical work in coding, and it should be relegated to the machine. I would be willing to gamble that you may wind up in the long run with the machine doing a great deal of the coding. This will leave to humans the part involving *judgment and intelligence and the problem of saying what the problem is.* This is going to put greater and greater emphasis on the combination of *resourcefulness and a wide breadth of knowledge.*"

Judgment, intelligence, resourcefulness: these are the essentials. How you achieve them is largely a matter of taste.

What Does a Young Engineer Want from His Education and How Can He Get It?

JOHN GAMMELL

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> "The destiny of any nation at any given time depends on the opinions of its young men under five and twenty."
> Goethe

We have asked a number of young engineers what they believe their engineering education should do for them. Many of them state the usual stereotype—to gain a knowledge of the physical laws of nature and a skill in using them. The implementation of this simple statement, like the promotion of virtue, is important and difficult, but in this article we shall address ourselves to other areas and, we hope, arrive at a helpful conclusion.

John Gammell

One young man listed a group of items and then ended with "My engineering education should allow me to communicate my results effectively." He enlarged on this by saying, "In few instances are we asked to reach an engineering decision for our own benefit but rather we relay the information to someone else. If results cannot be told clearly, the problem need not have been solved; time has been wasted." Certainly an engineer is most careful in all his dealings to be accurate, but is he equally careful to be understood? Does he know how to get attention and keep it?

John Gammell received his bachelor of science and electrical engineering degrees in 1928 at The University of Washington, Seattle, Washington. He reported directly to Allis-Chalmers in the same year and has been with the company almost continuously since that time. For approximately three years during World War II, John was with the War Production Board in Washington as Chief of its Electrical Equipment Branch. Prior to assuming his present position with the company, he had been a graduate training student, a sales representative with the Philadelphia Office of Allis-Chalmers and Supervisor of Sales Training. Mr. Gammell has written a number of articles and lectured extensively throughout the country on matters concerning the recruitment, training, and professional development of graduate engineers. He is a registered professional engineer; a member of the American Society for Engineering Education (Relations-with-Industry Division), and 1955–58 was the Treasurer for the national society; American Society of Mechanical Engineers; American Institute of Electrical Engineers; Wisconsin Society of Professional Engineers, where he nows holds the position of President. He is active in various organizations and committees associated with engineering education and the professional development of coming generations of engineers.

Another young man, after some interesting remarks, indicated that he placed a high value on his engineering education as an entering wedge into a good career. What could be more basic than this? In other words, my education should help me get a good job.

We are hearing much about prestige factors nowadays. A recently graduated engineer came up with the belief that his education "should provide assurance that a career in engineering is worthwhile and something to be proud of." What, indeed, is any life without a feeling of usefulness?

Along these lines we gathered an additional bit from a different source—the exact quote is: "The fact that a man is a graduate engineer gives him a certain amount of prestige among his friends and in the community in which he lives."

Perhaps a deep-seated need which everyone has is to escape from boredom. A young engineer I know states it this way: "Possibly, however, the most important reason a person becomes an engineer is the challenge it offers. The work he does is not routine."

We have here four basic ideas.

1. An engineering-educated man should be able to communicate wherein he is educated.
2. An engineering-educated man should find it easier to obtain a better job.
3. An engineering-educated man should be secure in the importance of his calling.
4. An engineering-educated man should have a better chance of escaping from routine and boredom.

Common experience of recruiters would seem to establish a high validity for all of these observations. Students by and large tend to jobs which present themselves as giving glamour, prestige, freedom of action, attention by management, and a chance to hit the jackpot of fame or riches. They want an education that helps them acquire all this and the knowledge of natural laws and skill in their use is but a means to a satisfying end.

Can we, under present world conditions, give young men such an education? Are we diverted too much by immediate problems? As an example we seem more and more to regard our engineering education and perhaps *all* education as having for its prime purpose the keeping ahead of Russia. It is a good purpose, but is it enough?

The Russians, for instance, have adopted a standard of education based largely on technological proficiency and, to a certain extent, the U. S. A. seems to feel it must do likewise. This leaves the acquisition of a broad education vested in studies pertaining to the humanities to the inclination of the individual. An engineering school in four years has no time for so-called culture.

It seems to me, then, that the crucial point here is to decide whether our national survival must depend upon highly developed scientists and technologists who, while seeking what the amenities and culture of life may bring, still know little or nothing of them. Unwittingly, many care nothing about them either.

Must our concern with Russia eliminate the deeper philosophies of education? If not, how can we inculcate during the period of formal education at the college a desire on the part of the student to continue his total development, to read broadly and participate in those professional and community activities that produce a man of status, a man who knows how to continue his technical growth but knows also how to fit to advantage his profession and himself into the life of his community. This kind of education will have to be carried on largely on his own time, if he can find such time during his college days. After college it must be attacked with purpose, if his real goals are to be attained.

The Engineers' Council for Professional Development's "First Five Years" program and its 6 points would seem to have an answer for all this. It is a postgraduate improvement program suggested by

1. Career Orientation
2. Continuing Education
3. Professional Identification
4. Responsible Citizenship

5. Selected Reading
6. Self Appraisal

This program includes much help toward the realization of the hopes of young engineers. Freedom from insecurity; freedom from being considered a nonentity; and freedom from boredom. Let us give these young men some help in continuing their professional development through introduction of the ECPD ready-made program. They will do the rest, for as Bacon said:

"The invention of young men is more lively than that of old and imaginations stream into their minds better."

FORD FOUNDATION HONORS PROGRAM GRANT

The Ford Foundation has awarded a grant of $700,000 to the Polytechnic Institute of Brooklyn to establish an honors program in science and engineering. Under the new program exceptional students will be able to receive a doctorate in six years of full-time study.

In announcing the receipt of the Ford grant, Dr. Ernst Weber, Polytechnic president, noted that approximately 6% of the Institute's September freshman class will be enrolled in the honors program.

Under the new program, no strict dividing line is provided between undergraduate and graduate work. A common core curriculum, concentrating in mathematics, physics and the humanities, will be given to all honors students in the first two years. At the end of the second year, students will begin specialization in selected areas, including chemistry, mathematics, physics, astronautics, chemical engineering, civil engineering, mechanical engineering, or metallurgical engineering.

Although the program is designed to educate research scientists and engineers from the freshman year through the doctorate, students will be awarded a bachelor of science degree at the end of the undergraduate portion of their studies. In addition to special curricula, the honors students will take part in seminars and special lectures given by visiting and foreign lecturers and will pursue faculty-supervised research projects early in the program.

Dr. Weber noted that the honors program was designed for "the exceptional student whose full potential is not challenged adequately by the average college curriculum."

The Ford Foundation grant, which may be used over a five-year period, will allow the Polytechnic to release faculty members from normal teaching loads, to invite visiting faculty members from other institutions, and to award fellowships and loans for graduate students in the program. It will also enable the Institute to develop new syllabi and develop experimental laboratory equipment.

Thirty-three of approximately 500 September freshmen have already been selected to take part in the program. All were at the top of their high school graduating classes, had excellent scores in the College Entrance Board Examinations, and were interviewed by the Honors Program Faculty Committee.

On the History of Kinematics of Mechanisms

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The kinematics of mechanisms, which has recently become a popular field for scholarly investigation in the United States, has a lively and colorful history extending back more than 175 years.

Machines of great ingenuity were recorded in books and manuscripts in increasing numbers from the time of Leonardo da Vinci (1452–1519), and a vast if ill-assorted repertory of ideas for mechanisms existed by the time Watt commenced his important work, around the time of the American Declaration of Independence. James Watt, adding to this storehouse of experience his own peculiar genius for devising new combinations, initiated a revolution in mechanisms that greatly increased the capacity and capabilities of steam engines and that was soon to extend to machines of every description. With the execution of his designs in the capable hands of Matthew Boulton, his partner, Watt was able to give to the world large and complex machines that operated dependably and economically over long periods of time.

This new concept of mechanisms took root in the mind of Gaspard Monge, one of the founders of l'École Polytechnique in Paris, in 1794, and the teaching of the principles of mechanisms to engineering students can be traced directly to his interest in the subject. Development of the ideas suggested by Monge was carried out by Hachette and by Lanz and Bétancourt, all scholars at l'École Polytechnique. The 1808 synoptic chart of Lanz and Bétancourt, exhibiting some 150 mechanisms on a single sheet, formed the basis for dozens of catalogs, dictionaries, and other compendia of "mechanical movements," used by designers in France, England, and the United States over the next century and a half.

Watt's brilliant synthesis of his four-bar approximate straight-line linkage was followed shortly by the "parallel motion," a combination of the straight-line linkage and a pantograph, which permitted a more compact configuration of his double-acting engines. "Though I am not over-anxious after fame," he told his son years later, "yet I am more proud of the parallel motion than of any other mechanical invention I have ever made."

Having shown the world that a solvable problem—that of tracing a nearly-straight line by means of a linkage employing only pin joints—existed, Watt lived to see several other solutions to the problem; and after his death in 1819 many more linkages were devised for the purpose of tracing a straight line. The urgent need for such a device, due to the absence of a satisfactory metal planing machine to make straight guides and adequate lubrication for a slider, was met by mid-19th century, but the quest for a more accurate straight-line linkage than Watt's continued for another generation. Indeed, several papers on this subject have appeared since 1950. The

This article is based upon Mr. Ferguson's "Kinematics of Mechanisms from the Time of Watt," which he presented on June 20, 1960 before a mechanical engineering session of the ASEE Annual Meeting at Purdue. The entire paper will be published as a part of Contributions from the Museum of History and Technology, United States National Museum Bulletin 228. Recommended for publication by the Mechanical Engineering Division.

most intensive work was done before 1880 by the Russian P. L. Chebyshev, who conceived the ingenious scheme of compounding straight-line linkages, letting the output of one linkage be the input to another, thus decreasing the deviation from a straight line of the final output tracing point, and by a group of English mathematicians, including J. J. Sylvester and A. B. Kempe.

The first exact straight-line linkage was described by Charles-Nicolas Peaucellier, a graduate of l'École Polytechnique, in 1873. News of its existence reached England by way of Moscow, for John James Sylvester was told about it by Professor Chebyshev when the latter visited London late in 1873. Professor Sylvester's reaction to the news was intense and spirited, and within a few weeks he gave a lecture on "Recent Discoveries in Mechanical Conversion of Motion" at the venerable and justly famous Royal Institution.

The Peaucellier linkage was adapted by Mr. Prim, Engineer to the Parliament, to an enormous blowing engine that he was building to ventilate the House of Commons, and Mr. Penrose, architect and surveyor to St. Paul's Cathedral, "put up a house-pump worked by a negative Peaucellier cell, to the great wonderment of the plumber employed, who could hardly believe his senses when he saw the sling attached to the piston-rod moving in a true vertical line, instead of wobbling as usual from side to side."

Several alternatives to Peaucellier's linkage were devised by Englishmen, and the whole subject was brought to a fitting climax in a popular lecture in 1876 by A. B. Kempe, entitled "How to Draw a Straight Line."

Graduates of l'École Polytechnique had earlier contributed many incisive ideas to the analysis of mechanisms. Remembered particularly is the 1834 paper by Gaspard-Gustave Coriolis, in which was explained the nature of the acceleration that now bears his name.

The academic development of kinematic analysis owes much to Robert Willis, professor of natural and experimental philosophy at Cambridge University, who published in 1841 his book on *Principles of Mechanism*. Stating clearly the idea that the motions in a mechanism could be analyzed without reference to forces that must be transmitted by its members, Willis was one of those who prepared the way for the fundamental and lasting work of the German, Franz Reuleaux, whose 1875 book *Theoretische Kinematik* was quickly translated into Italian, French, and English. The English translator, A. B. W. Kennedy, added the law of three centers, known as Kennedy's theorem, and Robert Henry Smith, professor of engineering at Mason College (now University of Birmingham, in England), presented in 1885 the graphical analytical procedures that he called velocity and acceleration polygons. By 1885 nearly all of the tools for modern kinematic analysis had been forged.

Engineering colleges in the United States were occupied until the late 1940's with extending, refining, and sharpening the ideas that were stated by Coriolis, Willis, Reuleaux, Kennedy, and Smith. Original American contributions to the kinematics of mechanisms have appeared only within the last dozen years.

A Conference on Mechanisms, sponsored by Purdue University and *Machine Design*, was inaugurated in 1953. Six conferences have been held thus far, including one in October, 1960, and response has been enthusiastic. Among other manifestations of current interest in mechanisms, the contributions of Americans to international conferences on mechanisms reflect the growing recognition of the value of scholarly investigation of the kind that can scarcely hope to yield immediately tangible results.

The proper role of rational methods in the synthesis—design—of mechanisms is not yet clear. "While we may talk about kinematic synthesis," wrote one of today's leaders in the field, "we are really talking about a hope for the future rather than a great reality of the present." When the mental equipment and the enthusiasm of scholars who are devoting their time to the problems of kinematic synthesis are considered, however, it is difficult to see how they can fail to produce important new ideas.

The Relationship of the Teacher's Knowledge of the Student's Background to the Effectiveness of Teaching

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I. Introduction

College teachers sometimes contend that they could do a more effective job of teaching if they had more information about the backgrounds of their students. In such instances, the term "background information" usually refers to data about the students' previous training and experiences and their current status.

Expressions of this kind are also often made in support of administrative policies which place limitations upon the size of classes. Usually, the specific point of contention is that whenever classes are increased in size, the teacher is less able to know the students as individuals and the consequence is that less effective teaching takes place.

With enrollment trends indicating that there will be an increasing number of students enrolled in our colleges and universities during the next several years, it is not unreasonable to expect that many colleges may be forced to increase the size of classes to accommodate this increased number of students. In anticipation of this situation, many educators are exploring the possibilities of closed circuit television, teaching machines, and other kinds of audio-visual aids which will permit instructional programs to function with larger student-teacher ratios.

If student-teacher ratios are increased, teachers will have larger numbers of students in their classes and they will thus find it increasingly difficult to know their students as individuals apart from the group. The question then arises, to what extent teaching effectiveness is related to the teacher's knowledge of the personal backgrounds of the students.

This discussion describes an investigation conducted to determine some measures of the extent to which the effectiveness of teaching is related to the teacher's knowledge of the student's personal background. Although recognizing that there are other criteria of teaching effectiveness, it should be pointed out that this investigation was limited to the consideration of only two such criteria: (1) the student ratings of the teacher and (2) the achievement of the students.

II. Design of the Investigation

The investigation was experimental in design and involved six groups of students taught by three teachers in the School of Physics at the Georgia Institute of Technology during one academic quarter. The specific course of study pursued by the six groups of students was the first course in sophomore physics (mechanics) which is required of all engineering students enrolled in the Institute.

Each of the three teachers taught two groups of students. One of the two groups taught by each teacher was designated as an experimental group; the other group taught by each teacher was designated as a control group. The single independent variable introduced into the experimental situation was the teacher's increased knowledge of the personal

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backgrounds of the students. Except for the effects of this variable, the classroom and laboratory experiences of all the students included in the investigation were assumed to have been identical. In other words, all other variables related to the classroom and laboratory procedures were assumed to have been either equated or held constant under controlled conditions.

Student Participants: The students included in the investigation were those who through the normal registration procedures of the Institute were assigned to the sections taught by the participating teachers. Even though random sampling techniques could not be employed in the selection of the students, it was assumed that the samples of students included in the investigation were randomly and independently drawn from their respective populations. This assumption was believed to be reasonably valid since the number of variables in the registration procedures which generally determine the section to which a student is assigned are so many that it would be most unlikely for the samples to be significantly different from samples selected at random.

Designation of Groups: Although it was not possible to randomly select either the teachers or the students, it was possible to randomly designate which of each teacher's two groups of students would be an experimental group and which would be a control group. This random designation was accomplished by tossing a coin.

Basic Assumptions: Two of the assumptions basic to the investigation were:

1. It was assumed that any teacher who was interested in participating in the investigation would increase his knowledge of the personal backgrounds of his students if given an increased amount of information about the students.

2. It was assumed that the participating teachers would use their knowledge of the personal backgrounds of the students in a variety of ways and to varying degrees. Thus, it was assumed that what would be an effective use of the background information for one teacher would not necessarily be an effective use of the information for another teacher.

Basic Hypotheses: Studies preliminary to the investigation had indicated that there is no significant correlation between the achievement of students and their ratings of teachers. For this reason, it was assumed that there were two independent hypotheses basic to the investigation:

1. Students will give their teachers higher ratings whenever the students are taught by teachers who have an increased knowledge of the personal backgrounds of the students.

2. Students will make greater achievement whenever the students are taught by teachers who have an increased knowledge of the personal backgrounds of the students.

III. Procedures

The procedures in the investigation involved the introduction of the independent variable and the securing of the criterion measures of teaching effectiveness.

Background Information: The information about the personal backgrounds of the students in the experimental groups consisted of: (1) a transcript of each student's college and secondary school record and (2) a personal data questionnaire filled in by each of the students in the experimental groups at the beginning of the investigation.

The questionnaire was a means of furnishing the teachers with information about the student's family background, his home community, his marital status, his own family, his college residence, his hobbies and special interests, his extracurricular activities in both high school and college, his goals in life, his field of specialization, his financial status as a student, his part-time employment, some of his personal problems, and his physical condition. The questionnaire thus provided the teachers with a much greater than normal amount of information about the personal backgrounds of

the students in the experimental groups.

Teacher Ratings: The ratings of the teachers were secured through the use of the Georgia Tech Faculty Evaluation Form which was filled in by each of the students at the conclusion of the investigation. The evaluation form consisted of a list of twenty-five criteria with instructions to the students to use the following set of values in expressing their judgments of the teacher's effectiveness with reference to each criterion: 5 (superior), 4 (very good), 3 (good), 2 (fair), 1 (poor).

Student Achievement: The achievement of the students was measured through the use of the Mechanics Section of the Cooperative Physics Test for College Students published by the Educational Testing Service, Princeton, New Jersey. This test was administered to the students at the beginning and again at the end of the investigation. Thus, it was possible to express the achievement of the students in terms of the gains in their knowledge of mechanics as measured by the differences between their beginning and ending scores on the test.

It was realized that the students' gains in achievement could be affected by certain variables other than the teachers themselves. The three such variables assumed to be most directly related to the students' gains in achievement were: (1) the students' knowledge of mechanics at the beginning of the investigation, (2) the general motivation of the students to succeed in their academic endeavors, and (3) the general scholastic aptitudes of the students. It was recognized that other variables existed, but for the purposes of the investigation their combined effects were assumed to be random, i.e., independent and normally distributed, with zero means and common variances, and thus having no effect upon the gains in achievement of the students.

The measures of the students' beginning knowledge of mechanics were secured through the first administration of the Cooperative Physics Test. The criterion measures of the students' motivation were expressed in terms of their scholastic point averages prior to their participation in the investigation. The measures of the general scholastic aptitudes of the students were obtained through the use of the American Council on Education Psychological Examination which was administered to each of the students included in the investigation.

IV. Analysis of the Data

The analysis of the data involved the testing of the two hypotheses basic to the investigation. The first hypothesis was concerned with the student ratings of the teachers; the second hypothesis with the students' gains in achievement. In each case, the analysis of the data was concerned primarily with the differences between two methods of instruction: (1) the experimental method, in which the teachers possessed an increased amount of information about the personal backgrounds of the students and (2) the control method, in which the teachers did not possess an increased amount of information about the personal backgrounds of the students.

Teacher Ratings: The analysis of the student ratings of the teachers was made by employing analysis of variance methods. Through the use of a factorial design in the analysis of variance, it was possible not only to study the effects of the teachers and the methods of instruction, but also to determine the significance of the interaction between the teachers and the methods of instruction.

Student Achievement: The method employed in analyzing the gains in achievement of the students was basically the same as the method used in the analysis of the ratings, i.e., the analysis of variance. However, since the magnitudes of the gains in achievement were assumed to have been related to the students' scholastic point averages, their scholastic aptitudes, and their beginning knowledge of mechanics, it was necessary that the students' actual gains in achievement be adjusted for the effects of these three variables before analyzing either the teacher or the method effects. In this respect, the analysis of the gains in achievement differed from the analysis of the ratings.

By employing methods of regressions, it was possible to adjust the students'

TABLE 1

ANALYSIS OF VARIANCE OF TEACHER RATINGS
Experimental Mean—3.9558
Control Mean—3.8039

Source of Variation	df	Sum of Squares	Mean Square	F
Teachers	2	5.2438	2.6219	11.6945*
Methods	1	1.5226	1.5226	6.7913*
Interaction	2	0.1162	0.0581	0.2591
Residual	258	57.8411	0.2242	
Total	263	64.7237		

* Significant at the 1% level.

actual gains in achievement (ending scores minus beginning scores) for the effects of the three concomitant variables and then to study the adjusted gains in achievement by using customary analysis of variance procedures. In effect, the procedure was a synthesis of regression methods and analysis of variance methods—sometimes referred to as the analysis of covariance.

V. Findings

The findings in the investigation are summarized in two tables—one for the analysis of the ratings and one for the analysis of the gains in achievement. However, in order to interpret these findings a criterion measure of significance was applied to each of the observed occurrences. The minimum criterion measure which was established for the purposes of the investigation was an F-ratio of such magnitude that the probability of the occurrence being due to sampling errors would be one chance in a hundred.

Teacher Ratings: As shown in Table 1, the students in the combined experimental groups rated the teachers higher than did the students in the combined control groups. This difference in the ratings was found to be significant at the 1% level. In other words, according to these data, students will give their teachers higher ratings whenever the students are taught by teachers who have an increased knowledge of the personal backgrounds of the students.

Also, as shown in Table 1, not only was there a significant difference in the ratings due to the methods of instruction, but there were also significant differences in the ratings of the individual teachers. Furthermore, according to the findings in the investigation, no significant level of interaction was found to exist between the teachers and the methods of instruction. This absence of a significant interaction was interpreted to mean that the teacher differences and the method differences were independent of each other.

Student Achievement: The results of the analysis of the students' gains in achievement are contained in Table 2. These findings show that the students in the combined experimental groups made significantly greater gains in achievement than did the students in the combined

TABLE 2

ANALYSIS OF VARIANCE OF THE STUDENTS' GAINS IN ACHIEVEMENT
Experimental Mean—13.3523 Control Mean—11.2218

Source of Variation	df	Sum of Squares	Mean Square	F
Overall Regression Effects	3	1,880.5264	626.8421	25.4948*
Differences in the Regression Effects	15	436.4100	29.0940	1.1833
Total Regression Effects	18	2,316.9364	128.7187	5.2352*
Teachers	2	427.5649	213.7825	8.6949*
Methods	1	245.1021	245.1021	9.9687*
Interaction	2	151.8694	75.9347	3.0884
Residual	192	4,720.7309	24.5871	
Total	215	7,862.2037		

* Significant at the 1% level.

control groups. Therefore, according to these data, students will make greater achievement whenever they are taught by teachers who have an increased knowledge of their personal backgrounds.

The findings also show not only that there was a significant difference between the methods of instruction, but that there were also significant differences in the gains in achievement of the students taught by the individual teachers. However, since the interaction between the teachers and the methods of instruction was not significant, the findings were interpreted to mean that the differences due to the methods of instruction were not dependent upon the teacher variable.

It should be further pointed out that, according to the findings in the investigation, the variations in the gains in achievement which were due to the overall regression effects of the three concomitant variables were found to be highly significant (see Table 2). In other words, the magnitudes of the students' actual gains in achievement were dependent upon the students' point averages, scholastic aptitudes, and beginning knowledge of mechanics. Thus, the adjustment procedures added to the validity of the tests of significance of the differences between the two methods of teaching.

VI. Conclusions

According to the findings in the investigation, the students not only made significantly greater gains in achievement, but also rated their teachers significantly higher as instructors when the teachers possessed an increased knowledge of the personal backgrounds of the students. On the basis of these findings, it was concluded that the effectiveness of teaching, as measured in terms of student achievement and student ratings of the teacher, is to a significant extent dependent upon the teacher's knowledge of the student's personal background.

It is recognized that the findings in the investigation were limited to the study of the student ratings of only three teachers and the achievement of only six groups of students in a single field of study (physics). Nevertheless, the high levels of significance which were found for the difference in the ratings of the teachers and for the gains in achievement of the students suggest that similar findings might be expected if such an investigation were to be repeated not only in physics, but also in other fields of study. To say the least, the findings in the investigation certainly provide evidence to support the need for further study of the relationships between the many functions of the teacher and the teacher's knowledge of the personal backgrounds of his students.

NUCLEAR STUDIES AT RENSSELAER

Rensselaer Polytechnic Institute, Troy, N. Y., has announced creation of a new academic department devoted to graduate-level teaching and research in nuclear engineering and science.

Dr. Clayton O. Dohrenwend, who as Provost of the Institute is in charge of its academic programs, said the department will be known as the Department of Nuclear Engineering and Science. It became operative July 1.

It will administer the expanding physical facilities of Rensselaer's present nuclear programs, including the Linear Accelerator Research Laboratory and Sub-critical Reactor Laboratory. These, with other facilities, will constitute the Rensselaer Nuclear Engineering and Science Center.

Schizophrenia in Engineering

HOMER H. GRANT

Associate Dean, School of Engineering, University of Southern California

As rates of change of modern science and engineering increase, confusion regarding the real meaning of engineering and the engineering profession also is growing.

I am reminded of the fable of the seven blind men trying to describe an elephant. You may recall that the blind man grasping the tail thought the elephant looked like a rope; the leg, a tree; the side, a wall, and so on. None envisaged the elephant. In a way each of us may be like the blind men. The engineering profession needs to make a greater effort to picture clearly the engineering "elephant" as a guide to its future.

With the increased use of engineers for fundamental scientific research, the engineering profession is developing a type of schizophrenia, used here in the lay sense of meaning split personality. The advent of Sputnik has further compounded the problem by emphasizing science.

Although the engineering profession appears superficially to be stronger and more important than ever before, it is actually facing a crisis which, left unresolved, may result not only in downgrading engineering but in seriously weakening the future strength of the Nation.

What are some of the reasons for this strange state of affairs and what corrective actions must be taken to avoid such disastrous eventualities?

The Traditional Role

The traditional role of engineering has been to turn the developments of the scientist in his laboratory into mass products for the use of mankind. Forty years ago this was a relatively simple concept. Rates of change were leisurely. The scientist stayed largely in his laboratory. The engineer restricted himself primarily to design and development, and to the more active pursuits evolving therefrom.

Two distinct types of men characterized science and engineering. The scientist was usually dedicated to exhaustive micro-investigation of extreme minutia in a very narrow field on the fore-front of knowledge, frequently a field of his own particular interest and choosing. On the other hand, the engineer had to meet and solve a wide diversity of problems. Usually these problems were in, or related to, his own field but were not of his own choosing. The engineer was expected to produce definite results within a given time period. To do this he called not only on his basic theoretical and experimental training but on broad experience, ingenuity, and a developed intuitive characteristic known loosely as engineering judgment. He practiced largely in fields of macro-investigations where theory needed to be accurate enough only for a desired result within general tolerances of safety, reliability, durability, and cost.

These facts were recognized as late as May, 1959, by President Eisenhower's Science Advisory Committee:

"The word 'diversified' should be emphasized, for individuals labeled 'engineers' perform a wide variety of tasks. . . . He is further distinguished from his colleagues in science in his constant concern to achieve an optimum design to meet the many and frequently conflicting criteria of performance, reliability, efficiency, cost and producibility. . . . The associated synthesis, analysis or design of an element or system are unique characteristics of engineering. . . . The profession of Engineering has thus

Presented at Annual Meeting, Pacific Southwest Section, ASEE, Los Angeles State College, December 28, 1959.

become one of the most important in modern society."

Gradually the demands for engineers spread from development and design into certain types of operations and management. This was occasioned not by the engineering profession but by the rising technical complexity of services and products, necessitating decision-making at ever higher levels by persons qualified by training to understand the technical implications of such decisions. For this reason *Fortune Magazine* could report several years ago that nearly half of the top three men in the 800 major manufacturing companies of the Nation had been trained as engineers. Forty years ago most of these positions were held by accountants, lawyers, financiers, and self-made production men.

Expansion in Research

With the advent of World War II and later the cold war, the Nation undertook a tremendous expansion of applied research and production requiring super-precision methods, often utilizing relatively new and unknown materials. Owing perhaps to the lack of applied scientists, the spectrum of engineering rapidly expanded into fields of applied research approaching basic research. In turn many scientists were drawn to fill needs in engineering, blurring traditional distinctions in the research and development spectrum. Note, however, that this expansion has not relieved engineering of its responsibilities in other areas.

Engineering education rapidly girded to meet the needs for increasing levels of technical attainment, as well as increasing numbers of engineers, a process continuing at an accelerated pace. Applied scientists appeared on the staffs of engineering colleges, infusing a healthful cross-fertilization. Unfortunately, but naturally, in many instances they brought narrow viewpoints concentrated almost entirely on the basic research portion of the engineering spectrum, with little understanding or interest in engineering as a profession serving the public and conforming to a code of ethics.

Engineering licensing laws, now effective in all states, were originally drawn to protect the public from unqualified persons offering to practice as professional engineers. Although still in process of evolution, these laws do not relate primarily to the research part of the engineering spectrum. *Professional registration as a criterion for engineering faculties is declining rapidly as emphasis on basic research increases.* Without attempting here to assess the desirability of this trend, it would seem the professional engineering societies and the engineering teaching profession should give greater consideration to definite objectives and courses of action for engineering.

To drift inadvertently into a situation which will determine the future of engineering by default would seem to be inexcusable. Even now many uninformed persons see no reason why a school of engineering should not be headed by a pure scientist. The sign of professional recognition for the scientist has long been the research doctorate (the Ph.D.), whereas for the engineer it has been primarily the license to practice as a Professional Engineer, consulting status, and salary. Availability of government funds for fairly fundamental applied research, and the need for research men in industry, have led to the development of such research organizations in engineering schools, and to the need for young men with the Ph.D. on engineering faculties. In my opinion this should benefit the profession when the Ph.D. is in engineering, or when an interest in training engineers exists even though the Ph.D. is in science. The benefit is not so tangible when a faculty member is truly interested only in training applied scientists, or is primarily interested only in research *per se*.

Should the distinction between the applied scientist and the engineer again be revived, or does the distinction no longer exist? Should engineering develop its own professional doctorate for those who do not wish to be primarily in highly basic research? Possession of a doctorate is beginning to be important in areas outside of basic research.

Medicine has long had its own doctor of medicine degree, which academicians

rank below the doctor of philosophy degree. On engineering faculties, possession of the Ph.D. degree sometimes engenders a reluctance to introduce doctorates of "lower rank." Although such distinctions may seem preposterous to practicing engineers, the effect on the future of the profession can be serious.

The situation in engineering today is not unlike that which would exist in medicine if research medical doctors suddenly began to feel that research was the only important aspect of their profession, and if the practicing medical physician was suddenly downgraded to a second class status.

Even worse, the qualifications for engineering are in grave danger of being regarded as secondary to those for science, if indeed this has not already happened.

In high school counseling, where the future of engineering really lies, the brightest students are being urged to go into science. Such misinformed counseling can be the death-knell of engineering, and in the future can greatly weaken the Nation. Counselors have often had some training in science but seldom in engineering; they may be unduly influenced by the scientific aspects of Sputniks, forgetting the engineering aspects.

For a strong Nation we must have strong and coordinate science and engineering. The interest of students in particular types of activity must be determining, not relative intellect. To do otherwise is to say that all bright students should be scientists regardless of personal interest.

Toward a Solution

What should the engineering profession do about these problems? First, it should increasingly apply its own methods of engineering analysis to a greater extent at both bottom and top professional society levels to determine clearly what its future should be. Steps taken so far have been inadequate. Imagine the legal profession allowing either scientists or labor unions to determine its future by default. Second, it should take additional organized steps to see that its objectives are realized. Third, the engineering teaching profession through the American Society for Engineering Education should assist vigorously in the overall effort by implementing a strong grass-roots organization. It should then try to eliminate the confusion in its own thinking. The problem is too complex for a small group of men at the top alone.

A first step might also be to counter the public statements of certain persons that engineering is still plodding along with the methods of thirty years ago. Such statements may be made by the uninformed, or for internal consumption to prod and stir discussion. In either event, released to the general public, they do great harm to engineering; and they are not true. Good engineering schools attempt to evolve with the times in accordance with their own ideas as to how they may best serve the profession and the Nation, realizing that the pattern of engineering education today determines the engineer of tomorrow. Clarification of objectives by the profession itself would help the process materially.

PATTERSON PROVOST AT FENN

As the first step in a reorganization of Fenn College's administration, President G. Brooks Earnest has announced the appointment of William A. Patterson as Provost, the chief academic officer of the College. Patterson, who has been Dean of the School of Engineering since 1953, will hold both posts until his successor is appointed.

What's Going On in ASEE

ANNUAL REPORT OF THE SECRETRAY OF ASEE, 1959–60

(Abridged to avoid duplication with other reports)

The purpose of the Secretary's Report has been to present, in one place, a brief account of his activities as well as an accounting of what transpired during the year in all phases of Society activities. Thus significant comments about finances, next year's budget, the JOURNAL OF ENGINEERING EDUCATION, ECRC, and ECAC are included even though such activities are covered in more detail in other reports. In addition, this report contains some recommendations for the future.

1. *Finances.* The pro-forma statement indicates that the Society had a good year financially. The receipts of about $140,000 exceed the budget of $132,200 by about $7,800, due primarily to the increases in advertising income and interest and the recovery of wages and indirect costs from special projects. The expenditures of about $130,000 are about $2,200 less than the amount budgeted and about $10,000 less than the income. Because of this favorable balance, after the budgeted $5,000 is transferred to the emergency reserve, it is recommended that a total of $15,000 be transferred to the emergency reserve, any needed additional amount to come from the unappropriated surplus now amounting to $9,210; any amount in excess of the needed $15,000 should go into the unappropriated surplus.

One new aspect of financing was the investment of temporarily surplus funds in U. S. Treasury Bills. This is possible because dues income is great early in the year and expenses relatively uniform throughout the year. The funds for special projects are handled in the same manner. Interest in the amount of $2,702.50 was earned in this way. Indirect costs from special projects accounted for an income of $1,110 and "recovery of salaries" of $2,270.

2. *Audit for 1958–59.* In last year's pro-forma statement it was anticipated that there would be a minimum deficit of $2,000. This did not materialize due to "conservative estimates" and the transfer of funds from special projects in accordance with contract or grant provisions. The net income for the year was about $116,800 and expenses were about $116,000 (including $5,000 for the emergency reserve), leaving a net operating income of about $800.

3. *Budget for 1960–61.* The proposed budget of $140,860 is about $8,700 or 6.5% greater than for the current year. Most of the increase in income is from advertising and dues income, the same percentage increase being used for both. The increased expenditures are primarily for increases in salaries and wages, the JOURNAL OF ENGINEERING EDUCATION, and officers' travel. The planned allocation to the emergency reserve remains the same as in the past, $5,000, but the estimated interest on investments also is allocated to the emergency reserve.

4. *Membership.*

a. *Individual.* During the fiscal year, to June 13, a total of 952 new members joined the Society, bringing the total membership as of that date to 9,529, the highest on record. After the appropriate drop action on members the total will be 9,369. A study of the number of new members for a given year relative to the total number of members listed in the next Yearbook indicates that the "net gain factor" is 0.57. In other words deaths, resignations, and drops counterbalance about 43% of the number of new members. Some comparative statistics for the past few years follow:

	55–56	56–57	57–58	58–59	59–60
Individual members (Yearbook)	7,548	7,450	8,067	8,753	9,120
New individual members	639	855	1,059	969	952
Life members	23	26	18	25	45
Resignations	297	210	129	184	214
Deaths	51	46	39	51	61
Delinquent one year's dues	352	364	362	418	520
Delinquent two years' dues (to be dropped)	266	164	155	160	211
Address unknown	64	12	31	24	35
Applications to be approved[1]	85	8	39	12	52
Individual dues income	$53,343	$54,127	$58,483	$62,169	$73,580

[1] Included in "New Individual Members."

These figures indicate that the increase in individual dues of $1.00 per member caused no appreciable unfavorable reaction, although the number of delinquents, resignations and life members all are higher than for the past four or five years.

The membership drive again was conducted through the YET Section Representatives and the institutional representatives they selected or which were otherwise designated. The results lagged greatly during the first half of the year, but continued prodding late in the year brought good results. Each member institution was requested to report the number of full-time faculty members and the number belonging to ASEE. About one-third of the institutions replied, reporting that an average of about 50% are members of ASEE. Thus, in our colleges of engineering, as well as in industry and in technical institutes, there still is a large potential of new members and an effective membership drive again should be planned. It is recommended that a different plan be used next year. The efforts of Divisions to bring into the Society the leaders in their areas who ought to be members are still spasmodic.

b. *Institutional.* No organized efforts to promote any kind of institutional membership were made. It was hoped that both industrial and associate memberships could be expanded, but in the former case valid reasons prevented the naming of a chairman who could serve long enough to get a plan under way, and in the latter case the committee just didn't function. The trends for the past few years are indicated by the Yearbook totals given below:

	Feb. 56	Feb. 57	Feb. 58	Feb. 59	Feb. 60	June 13, 1960
Active	148	152	152	154	155	158
Industrial	110[1]	131[1]	132	147	180	184
Associate	—	—	9	9	16	15
Affiliate	29	39	41	56	69	72

[1] Industrial and Associate not separated.

The number of industrial members resigning during the year is 3, and 5 have dues unpaid for 1959–60; last year the figures were exactly the same. A study of the costs of the benefits received by various members was started, with the objective of an ultimate revision of the dues for institutional members; they are unchanged since 1956–57, prior to which they were $15 per year.

5. *Subscriptions.* Information on subscriptions to the JOURNAL OF ENGINEERING EDUCATION annually is given to major subscription agencies, both domestic and foreign, and this must be the reason for the continued steady increase in the number of paid subscriptions. Compara-

tive figures from totals in the Annual Reports for the past three years are 1958... 432; 1959...497; 1960...565.

6. *Publications.* The production of the JOURNAL OF ENGINEERING EDUCATION has been systematized so that it continues to be in the mail during the first half of the appropriate month. The Yearbook-Directory still causes some trouble, but studies are being made to overcome it. The total number of pages printed during the year, exclusive of advertising but including the 72-page final report of The Committee on Development of Engineering Faculties, is 908. Papers still are coming in at a rate which permits the selection of about one out of five papers for publication. The Editorial Committee is functioning satisfactorily. Few papers will be carried over to next year without a decision regarding their disposition.

The regular publication of the *Nuclear Engineering Education Newsletter* continued under the sponsorship of the Atomic Energy Commission.

New Publications during the year are:

1. Engineering Faculty Recruitment, Development, and Utilization
2. ECRC Research Review–1959
3. Do You Need More High Quality Ph.D. Engineers? (A brochure describing industrial fellowships.)

The responsibility for the editing and publication of the ECRC Research Review has been transferred from the Secretary of ECRC to the Editor of the JOURNAL, and the promotion and sale of copies has been transferred to the Secretary of the Society. A total of 553 copies have been sold to June 13. It is recommended that the cost be increased from $2.00 to at least $3.00 per copy in order that income more nearly equal the cost of printing, which is almost $5,000, and in order that ECRC's financial position be enhanced.

7. *Advertising.* The amount of advertising in the JOURNAL OF ENGINEERING EDUCATION increased 27.1% from a total of 162.5 pages for last year to 206.5 pages. This is the largest total number of pages since 1954–55. This increase is greater than what was budgeted, and indicates that the direct mail promotional campaign is bringing results. The big difference between current advertising and that of five to ten years ago when it averaged about 225 pages is the amount of equipment advertising by industry. Currently 85% of the book publishers' advertising and 92% of the industrial advertising are by institutional members. Despite the increase in advertising income of $4,500, advertising income still pays for only about two-thirds of the cost of *printing* the JOURNAL. Getting the two equal thus still is an objective of the future, and it means that extensive promotional efforts to increase the amount of advertising must continue.

8. *Office Staff.* The addition of a half-time Assistant Secretary for the academic year was of inestimable value. Without that help the Visiting Engineers and the Summer Institute programs could not have been administered without much other work suffering extensively. As it is, some services have been improved and some things previously undone were accomplished.

Planning time for the Secretary still is the biggest problem. The amount of daily correspondence, particularly that which can be classified as "public information," continues to increase; this year the marked increase was in the technical institute area. The Secretary again was relieved of his one-quarter time teaching assignment in order to administer the ASEE–AEC Summer Institute program. The continued cooperation of Professor T. J. Dolan, Head of the Department of Theoretical and Applied Mechanics, is sincerely appreciated. A preliminary analysis of the time of the entire headquarters staff indicates the following distribution of effort:

Work Item	% of Time[1]	% of Total Salaries
Journal	190	17
Special projects	210	22
ECAC	15	2
ECRC	30	4
Membership	165	17
Yearbook	95	7
Public Relations	115	18
Annual Meeting	45	7
Supervision	35	6
Totals	900%—9 employees	

[1] One person is 100%, regardless of amount of time directed to ASEE.

9. *Office Equipment.* The continued need is for an easy-to-operate machine to produce 15 to 75 copies of letters and reports. To reduce the amount of mimeographing, to get better copy and to reduce the amount of work in the office, the multilith facilities of the University of Illinois stenographic pool have been used to an increased extent. Some mimeographing and folding also has been done in the Publications Office of the College of Engineering and its addressograph plates are used for news releases. This time cooperation is sincerely appreciated.

10. *Office Space.* There is a real need for better quarters for the Assistant Secretary. It is believed this can be arranged on a temporary basis for little cost. The College of Engineering, which has jurisdiction over the former residence housing ASEE, has been requested to consider certain alterations to permit more effective use of the space and to redecorate the interior.

11. *Travel of Headquarters Staff.* During the year 47 meetings and conferences were attended by the Headquarters staff. It should be noted that the nature of the Secretary's travel includes several "planning conferences," something that has been increasing during the past two years. Also, not all travel required payment by the Society.

12. *Public Relations.* Some of this work, particularly as it applies to news releases, gradually is being absorbed by Society headquarters and less and less dependence is being placed on the Chairman of the Public Information Committee. It is believed this is a good trend, but how far it can go, and how fast, is a big question. The preliminary analysis of time allocations of the entire office staff indicated that more than one person's full time in services, about $8,000 in salaries, which is about 18% of the total of salaries paid, already is devoted to what can be called public relations. Time-wise this is the fourth largest of the nine categories of work listed in Article 8; dollar-wise it is the largest.

13. *Industrial Fellowships.* The Leeds and Northrup Foundation's fifth three-year fellowship was awarded to North Carolina State. The Committee prepared a brochure and it was distributed widely to industries and deans of engineering. No additional fellowships resulted, but at least one substantial prospect was uncovered.

14. *Summer Schools.* Three Summer Schools were sponsored by Divisions, all in connection with the Annual Meeting at Purdue, as listed below:

a. Industrial Engineering Division, June 18 and 19
"Frontiers of Industrial Engineering"

b. Electrical Engineering Division, in cooperation with the Relation with Industry Division and the Professional Group on Education of the Institute of Radio Engineers, June 23 and 24
"Workshop on Solid State Electronics"

c. Industrial Engineering Division, in cooperation with the American Society of Tool Engineers, June 24 and 25
"Metal Processing"

15. *Mid-Winter Meetings.* The usual three were held, as listed below:

a. Relations with Industry Division, College-Industry Conference, Washington University, St. Louis, Mo. January 27 and 28
"The Young Professional Engineer . . . Our Mutual Responsibilities"

b. Cooperative Education Division, Georgia Institute of Technology, February 11 and 12
"The Edison Foundation Report on the Study of Cooperative Education"

c. Engineering Graphics Division, Missouri School of Mines, January 20–23

16. *Special Projects.* a. *Humanistic-Social Research Follow-Up:* G. A. Gullette, Chairman. The project will come to a close with the publication of the papers from last year's Summer School in the JOURNAL OF ENGINEERING EDUCATION. The funds remaining in the project will be used to pay for the printing of the papers as "extras" to a regular issue.

b. *Survey of Technical Institute Education:* K. L. Holderman, Chairman. The final report was published as "The Technical Institute in America" by G. Ross Henninger. It was published by the McGraw-Hill Book Company as one of the Carnegie Series in American Education and is sold only by McGraw-Hill. A supplemental grant of $1,731 was received from the Carnegie Corporation to complete the project.

c. *ASEE–AEC Summer Institutes on Nuclear Energy:* Nuclear Committee. The six jointly sponsored eight-week summer institutes and the attendance at each are:

Basic Course	
1. North Carolina State and Oak Ridge National Laboratory	21
2. Purdue University and Argonne National Laboratory	23
Advanced Courses	
3. Advanced Radiation Effects—Theory and Experiment, University of Michigan	15
4. Special Nuclear Studies, Argonne National Laboratory	16
5. Intermediate Reactor Physics, North Carolina State	9
Technical Institute	
6. Pennsylvania State University and Argonne National Laboratory	19
Total	103

The number of attendees is considerably less than expected; only 136 applied. The number attending last year was 128. The backgrounds of all applicants were reviewed by selection committees to be sure those selected were qualified to handle the particular subject matter at the intended level. Plans are under way for additional programs next year, some possibly of shorter than eight-weeks' duration, particularly for teachers with experience in the nuclear area.

The Nuclear Committee also made extensive evaluations of the Summer Institute and the AEC Equipment Grant programs; they will be presented at the Annual Meeting and later published.

d. *Nuclear Energy Education Newsletter:* Nine issues were mailed to about 1600 people who requested being placed on the mailing list. The text for all issues was prepared by Professor V. E. Bergdolt of Purdue University; the Society headquarters maintains the mailing list.

e. *Technical Institute Book:* S. C. Hollister, Acting Chairman. No progress was made because the Secretary of the Society has not collected material for the Awards Procedure Committee. About $5,000 is in the fund.

f. *Development of Engineering Faculties.* H. L. Hazen, Chairman. The final report of the Committee was published in the May issue of the JOURNAL OF ENGINEERING EDUCATION as well as in separate form. A direct report to the Society constituted the program of ECAC's General Session at the Annual Meeting. A grant of $16,000 was received by ASEE from the Ford Foundation to support the Tau Beta Pi Opinion Study that Professor H. A. Foecke is working on as his doctoral thesis during the year 1960–61.

g. *Research on the Teaching of Engineers.* The proposal has been redrafted and discussed with representatives of the Ford Foundation, but no agreement has been reached. The annotated bibliography on research in teaching prepared by the U. S. Office of Education has been received and appropriate portions are being published in the JOURNAL OF ENGINEERING EDUCATION.

h. *Evaluation of Technical Institute Education:* C. C. Tyrell, Chairman. A proposal has been approved for presentation to a foundation for support. It is hoped financing soon can be arranged.

i. *Objective Criteria for Nuclear Engineering Education:* Glenn Murphy, Chairman. A contract with the Atomic Energy Commission for $35,400 has been signed. The joint committee, with the American Nuclear Society, has been appointed and an organizational meeting was held of those attending the Annual Meeting.

j. *Visiting Engineers Program:* C. C. Chambers, Chairman. The program has been extended to January 1, 1961. Five visits were made during the spring and preliminary arrangements have been made for the remainder during the fall. A proposal to extend the program beyond January 1, 1961, was submitted to the

National Science Foundation during the summer.

k. *Pan-American Congress on Engineering Education:* EJC, ECPD, and ASEE. Engineers Joint Council, on behalf of itself, the Engineers' Council for Professional Development, and ASEE, received a grant of $11,350 from the National Science Foundation for a mutually agreed upon team of five to present papers at the Pan-American Congress in Buenos Aires. The Secretary of the Society received a grant from the Ford Foundation in order to officially represent ASEE and to be able to accept the invitation of the State Department to spend a month consulting with the National University of Paraguay regarding its engineering program.

l. *Survey of Undergraduate Equipment Needs:* R. J. Grosh, Director. A contract is being negotiated with the National Science Foundation for a quick survey of the undergraduate equipment needs. Four other societies are making a similar survey in order that NSF can determine the magnitude of the problem and decide on a future program.

m. *Salaries and Income of Engineering Teachers:* This is a repetition of what was done in 1958 and 1956, jointly with the Engineering Manpower Commission of the Engineers Joint Council. A proposal for a grant will be submitted to NSF.

n. *Other Co-sponsored Programs:* During the year the Society served or agreed to serve as a co-sponsor, without financial responsibility but with the right to appoint a representative on the planning committee, of the following programs:

1. Cooper Union Conferences on Civil Engineering Education
2. Mechanical Engineering Laboratory Instruction
3. Engineering Design Education Conference
4. Nature and Properties of Materials Summer School
5. YET Summer Institute

17. *Intra-Society Relationships.* The planning for the Annual Meeting programs was by far the best of any for the past six years. Few Divisions and Committees needed to be prodded. The greatest current deficiency is getting the various units of the Society to submit reports to the appropriate vice presidents. The second greatest deficiency is in getting those responsible for mid-winter meetings and summer schools to submit program information in time to be publicized in the JOURNAL OF ENGINEERING EDUCATION.

18. *Appreciation.* The fine cooperation of the national officers, the headquarters staff, section and division officers, and committee chairmen is hereby acknowledged. The desire to work for ASEE is truly phenomenal, and it can be said in all sincerity and truthfulness, "For the people had a will to work." Without that spirit on the part of the membership this annual report could not contain the record of achievements it presents. To all who did their share, and for their enthusiasm and tolerance, an expression of appreciation is extended. Those who worked made this a good year, and it is sincerely believed that the fine spirit now existing in ASEE will make next year even better.

Respectfully submitted,

W. LEIGHTON COLLINS
Secretary

NEW SCHOOL AT PURDUE

Purdue University announces the merger of the Division of Engineering Sciences and the School of Aeronautical Engineering to form a new school to be known as the School of Aeronautical and Engineering Sciences, effective July 1st. An Aero-Space Sciences Laboratory has been established for graduate research. Dr. Harold M. DeGroff will be Head of the new school and Director of the Laboratory. Dr. E. A. Trabant, Head of the Division of Engineering Sciences, had previously resigned to become Dean of Engineering at the University of Buffalo.

Candid Comments

This section is open to comments on articles in the JOURNAL or on engineering education in general. Send comments to the Editor, JOURNAL OF ENGINEERING EDUCATION, University of Illinois, Urbana, Illinois.

The Chronology of Subject Matter

No serious engineering educator will deny the importance of stressing the fundamental tenets of a particular engineering subject. For is it not true that all engineering problems require for their solution only the application of these few and simple principles? The problem and the principles are conveniently thought of respectively as a structure, and the building blocks of which it is comprised. The logical way to build a structure is to pile one block on the other, ergo, the logical way to teach comprehensive engineering problems is to first present with complete detail and rigor the engineering principles, and create mastery thereof by the student. For students with above average engineering aptitude, this approach ultimately pays the best dividends. I submit, however, that techniques of teaching must be selected according to the ability of the students, and that for students below average, the rigorous fundamental approach is not the most effective way to teach a given amount of subject matter. Unfortunately, there is usually no segregation with respect to student ability in most engineering schools, thus forcing instructors to choose a single approach which is aimed toward the average student in the class. It is interesting to note that grade schools do recognize levels of student ability by dividing a given grade into different sections, in which the subject matter is covered at various rates and with various degrees of thoroughness.

It can well be argued that we should not cater to below average students since this leads to lower engineering school standards. However, the American philosophy does not permit disregard for poorer students. Secondly, there must always be a gradation of abilities, regardless of how high the lowest level is. It can be assumed, therefore, that a spread of student capability will always exist.

The engineering teaching approach has been shifting rapidly toward the more rigorous, building block method. At the same time, however, engineering students have not cooperated by entering college with greater maturity. The shock usually experienced by students in their transition from high school to college is therefore becoming more and more severe. I believe this is a contributing factor to the increased number of drop outs and decreased enrollment in the engineering colleges in the past several years.

We can hardly deny that physics students reach a higher level of mathematical and physical sophistication in four years than do most engineers. Yet if we examine the undergraduate physics curriculum, we find that physics and mathematics are begun on a much less elegant level than they are for engineers. Subject matter is repeated two and three times at different philosophical levels. Clearly, although quantum mechanics is a fundamental building block in physics, no attempt is made to lay that particular block until the building is at an advanced stage of erection.

I appeal to engineering teachers, then, to reconsider the question of chronology in our engineering courses. Presentation in an order which appears to experienced engineers to be simple and beautifully logical, is not necessarily appreciated by young students of the average variety. We must exercise patience and introduce students to physical concepts by the more classical, descriptive methods before elaborating on a more rigorous level. From a viewpoint of mathematical logic, one derives the most general relationships first, then reduces the formulation to special cases by neglecting various terms in the general equations. However, ped-

agogically it is more desirable in most cases to go from the specific to the general. Certainly our understanding of the physical laws of nature has developed historically in this sense.

In conclusion, I wish to propose that we consider the segregation of students according to their intellectual maturity, so that classroom methods may be used which are the most suitable for each group. Failing this, I wish to sound a note of caution to engineering educators to beware that their own level of sophistication does not blind them to the realities of the average student's ability to appreciate the rigorous mathematical niceties. We are in real danger, not of having the proverbial "too little—too late" of World War II, but of giving the students "too much—too early."

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Computers in Engineering Education

The group of articles on "Computers in Engineering Education" in the June 1960 issue of the Journal was tremendously stimulating. They provided a wealth of ideas and of practical experience about the impact of computers on engineering education. Yet when I finished reading these articles a second time, I had the nagging feeling that an important aspect of the impact of computers had not been covered. Then it dawned upon me that each article—even those which paid the greatest attention to the interdisciplinary effects of computers—had tended to treat computers (or information processing) as something special: that is, as a distinctive technical specialty. However, computers and information processing techniques are also the results of evolution, and are themselves evolutionary agents operating upon current developments. Their effects upon the mainstreams of engineering development, particularly the development of large-scale systems, can and do go far beyond the well-recognized impact of the computational and mathematical capabilities they make available. This evolutionary viewpoint and the potential advantages of a rapprochement of computer education and the mainstream of electrical engineering education were not, I believe, given their due.

The rapid acceptance of computers as mathematical and business data processing tools and the consequent explosive growth of the computer field has tended to set computers off as a distinct technical field or specialty. This occurred quickly before their areas of fundamental unity and similarity with more conventional areas of electrical engineering were fully recognized and exploited in the "core" courses of most electrical engineering curricula. Thus it has frequently happened that specialized computer courses provided the only contact many students have had with computers and information processing concepts and techniques. I have no argument with treating computers or data processing as a specialty. The approach is valid and useful both in industry and education. For example, it leads directly to such useful (and proven) ideas as the "independent" computer facility available to all departments of a company or university. However, working in computer research and development for the past four years I have come to believe that it is equally important to integrate information processing topics into the fundamental development of electrical engineering concepts in education. These information processing topics can often act like leavening agents, stimulating the production of new and distinctly improved approaches to conventional electrical engineering problems.

Lest one think that the existence of this leavening effect is idle speculation unsupported by actual experience, let me cite the case of large-scale communications systems. The explosive increase in requirements for machine-to-machine data transmission (as contrasted to human-to-human communication) is today causing a major upheaval in communications. For example, in three years the requirements for data transmission jumped from virtually nothing to about ⅓ of the total communications load for the U. S. Army's worldwide Army Command and

Administrative Network (ACAN). The increased requirements for rate of transmission and accuracy are swamping conventionally designed systems. As a result it has been necessary to evolve new approaches, concepts and techniques to solve the problems. Statistical transmission techniques, the use of error detecting and correcting codes, the use of computers for data reduction prior to putting information into communications links, etc. are becoming practical realities rather than interesting theoretical possibilities. Central offices (switchboards and commcenters) which use computer techniques and even stored program computers as their control elements are being experimented with, and communications systems designers are turning more and more to both special purpose and general purpose computers as means of solving complex problems of routing, cryptographic system assignment, directory maintenance, etc.

New equipment developments are also beginning to blunt the distinctions between communications and data processing equipment. The U. S. Army's FIELDATA program makes no distinction between them, using common codes, interconnection characteristics, and even common equipment to perform either communications or data processing functions. The Army's UNICOM plan for global communications even envisions automatic data processing service centers associated with each major central office of the communications system. The U. S. Air Force has similarly recognized the importance of integrating communications and data processing information systems in the establishment of the new Command Control Development Division of the Air Research and Development Command. A key objective of this new organization is to integrate the various communications and data processing systems under Air Force development. Here too there are individual projects in which communications and data processing operations are so closely intertwined that they are difficult to separate, for example Project 465L, the Strategic Air Command Control System. Lest that one think that this tendency to integration is limited to the armed services, one also finds the Bell System actively experimenting with the use of stored program computers to control telephone switching (See "An Introduction to the Bell System's First Electronic Central Office" in the Proc. Eastern Joint Computer Conference, 1958).

If information processing and computer techniques were drawn into the mainstream of electrical engineering education, the approach would be completely compatible with the major historical trends in the development of electrical engineering. Historically the early concern of electrical engineering was with the conversion of energy from other forms into electrical energy, with the transmission and distribution of energy in electrical form, and with its control and reconversion for ultimate utilization. Thus about the time of World War I electrical engineering attention was centered upon "power," that is, the generation and distribution of large amounts of electrical energy, its conversion to mechanical energy in motors, its conversion to heat energy in furnaces, its conversion to light for illumination, etc. However, by gradual evolution as World War II approached, the center of attention gradually shifted towards "communications" where the electrical energy was used as a means of carrying information. Since World War II and the emergence of more sophisticated communications techniques and equipments, servomechanisms, and electronic computers, there has been a distinct tendency for electronic equipment to coalesce into ever larger and more complex communications-electronics systems. Large communications systems, air defense systems, missile ground control systems, and many others are becoming so complex that it has become increasingly difficult for system designers to keep track of the individual circuits in their systems. Naturally they have tended to lump larger and larger sub-assemblies into "black boxes" which they treat as a unit, and they have concentrated more and more of their attention in system design upon the flow and control of *information* almost as a separate entity from the control of *energy* to and within these same "black boxes."

To engineers working in such an environment the tools of information theory, statistical signal analysis, Boolean logic, computer organization and programming, and a whole host of new techniques associated with information concepts have assumed a place of importance equal to or greater than the more traditional topics of electrical engineering. Moreover, to people working in this environment the sharp dividing line tacitly assumed by many educators to exist between communications and data processing just does not exist. After all, a very significant proportion of the equipment in a modern communications system (particularly equipment in central offices and multi-channel communications terminals) is best described as information handling equipment, while an equally significant proportion of the equipment and operations within data processors is used in performing simple transfers of information from place to place within the data processing system. Thus to these engineers the distinction between "communications topics" and "data processing topics" is at best an arbitrary matter of convenience and at worst a considerable nuisance.

The increasing importance of information topics, including information processing topics, as a coherent area for study has been recognized by some educators and has been the basis for some rather startling and thought-provoking suggestions. The report by the Electrical Sciences Committee in the ASEE "Report on the Engineering Sciences 1956–1958" has, for example, advocated complete reorganization of electrical science curricula into an energy processing portion and an information processing portion. Among those educators with a less predominately electrical viewpoint one frequently hears the suggestion to create a separate "Information Processing Department" within universities, presumably following the lead of the independent or quasi-independent computation centers adopted so successfully by many universities. Such radical approaches are thought-provoking, but revolutionary changes in curricula and organization are often neither feasible nor desirable. What is needed by most universities is something more evolutionary which achieves the desired result without the disadvantages of such a sharp break with the past.

Over a period of years most universities have successfully negotiated an evolutionary transition from "power" orientation to "communications-electronics" orientation by absorbing the necessary communications-electronics topics and examples into their "core curriculum" courses. The pace has been deliberate, too leisurely in some cases, but the results have usually been successful. Contrast this to the tendency of many universities to *segregate* all information processing topics into special *computer* courses. No wonder the commonly taught survey of digital and analog computers is often considered so important and successful. It is often the *only* exposure many students get to information processing topics. Yet, by its very nature, such a course is usually a specialized course designed to give the student an awareness of the computer as a mathematical and computational tool and, perhaps, some appreciation for the electrical circuit and logical design techniques required for computers. Certainly one can make a strong case for such an orientation of this course. Every engineer, electrical or otherwise, should be given an opportunity to familiarize himself with the capabilities and limitations of computers as tools for mathematical computation and with general concepts of their organization and construction. Yet there is an equally pressing need not satisfied by many universities. Most engineers, particularly if they are electrical engineers, will some day be associated with the design, operation or development of assemblies for large-scale systems such as communications systems, surveillance systems, missile systems or some type of process control or weapons system. These engineers should be given an opportunity to familiarize themselves with the fundamental concepts and techniques for information handling and processing without discrimination whether these techniques arose out of communications practice or data processing practice. Today it is too often

the case that *only* those arising out of communications practice are taught in the core curriculum.

What should be done? I am sure there is no pat answer applicable to all cases. But I am equally sure that this is a topic intimately associated with the topic of "Computers in Engineering Education." This aspect of some of the experiments going on in introducing more generalized information processing courses (which could be absorbed into the core curriculum) deserves considerably more attention and discussion.

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The Human Approach

I have been receiving your periodic news releases to education editors, relative to the need for more students and teachers in the engineering fields. While I agree with you that the need is quite real, I have become increasingly concerned at the lack of one (to me, at least) important element in all your releases. As I read in your June 24th release about Dr. Carl W. Borgmann's address, I thought at last it had appeared; but, from your quotes of his speech, he by-passed the point, too.

I refer to the great need for educating engineers in the humanities, as well as in the disciplines of math, science and the technological subjects. Nowhere in your releases have I seen positive reference to this need; yet I see almost daily evidence of its absence in engineers with whom I come in contact. Let me tell you about two of these—different in age, background, alma mater, religion and particular field—but each with the same lack of humanity. Both serve on quasi-governmental units with which I have been closely associated through my work, so I have frequent and penetrating contact with them.

One is a graduate of an engineering field other than the one in which he is presently employed. He is young, the father of several children, tall, pleasant looking, married to a good looking young woman, active in a church whose American roots date back to some of our Founding Fathers, and an extrovert. Let us call him Bill.

The other teaches engineering in a highly respected institution of higher learning. He is small, middle-aged, the father of two children, married to a woman who has given unstintingly of herself to important community activities. He is a member of one of the major Protestant church groups in the U. S., and an introvert. Let us call him Sam.

Two men—different in every respect—except in their total disregard of people. It is more than a lack of understanding or appreciation of their fellow man; it is a complete absence of the knowledge that their fellow man exists, as a human being. To both Bill and Sam, people are objects to be manipulated—when and where it will serve their individual purpose. I have seen both, on various occasions but independently, in effect deny the right of another person to gather facts and draw a conclusion from these facts, because the fact-gathering method and/or the conclusion did not coincide with theirs. Each demands absolute acceptance of his conclusions—with no questions asked—simply because he is "an engineer" and trained in such things, where no one else outside the profession is so trained. Each reserves the right unto himself to question, probe, tear down, disparage and reject another's fact-finding, conclusions and intelligence; each, however, is above reproach.

Truth has no real meaning for either of them. I have heard each of them make statements of belief or policy (have even seen it in writing) which each has later—when it was expedient—denied as having ever existed.

One observer has called them "walking and breathing computers." I call them amoral. Yet, if one should speak to them about their behavior in terms of their religious backgrounds, they would be immediately affronted and indignant; for each considers himself a religious man.

You may say that this is only two out of hundreds; I use these two as examples of these hundreds, for I have seen their

counterparts in many areas of my life in newspaper work—among Catholics, Protestants and Jews. I speak of these two because the damage they are doing to their fellow men is greater because of their positions in their communities' quasi-governmental groups, than many of these others whom I know.

The teacher is the one who worries me most, for I have nightmares about the influence he can have on his young students. Bill is in no such broad position to pass on his concept of the immutable supremacy of engineering methods and of the obligation of non-engineers to obey, unquestioningly, the engineers' decisions; to accept, unquestioningly, the engineers' conclusions and recommendations.

Having a college-age son of my own, I know how impressionable these youths are, how easy it is to brainwash them with "superior" propaganda. Unless they are given the insight into what John Donne expressed as "No man is an island, entire of itself"; unless they truly come to understand that the effect on other people of what they do is the first and most important consideration in their future course of action on this earth, we are building another race of supermen, bent on imposing their superior will and knowledge on the rest of the world. Unless they come to truly believe that our system of government has devised institutions to serve men—not for men to serve the institutions—what kind of voting citizens will they become? What will happen to our governmental institutions as many of them take their places as officials of these governmental institutions?

Your releases have spoken of the need for passing on our engineering know-how to the underdeveloped countries of the world, to help them solve their social problems. But are not PEOPLE the victims of these problems; is not the basic purpose of solving these problems to improve the lot of the PEOPLE of these countries? Yet, unless these engineers-to-be are helped to see this relationship, have their sights raised beyond the slide rule, the equations and the drafting board, the end will have no relationship to the means, their own perfection as engineers and the perfection of the engineering approach to problems will become irrevocably implanted in their receptive minds.

I do not mean to imply that all engineering education is bad, or lacking in the humanities. I know other engineers —in various fields—who have a warm, sincere, outreaching approach to other people. But I have checked the background of some of these, and have found that theirs were the "different" engineering educations; i.e., one man studied at a church-related college where religion was a required course for everyone. Now, I am not suggesting in the least that all engineers should have to take religion; I merely state this fact as an illustration of "above and beyond" training—for one can hardly study religion without discovering that people are important as human beings.

In other cases, these "different" engineers frankly admit their "mechanical" courses, and credit strong family influence, earlier training, non-engineering courses which they elected to take, and like factors as being the reason they are not the "walking and breathing computers" like Bill and Sam.

You may well ask how these two, Sam and Bill, were able to get on their communities' groups. Sam was appointed on his own record of having joined in active, articulate support of the principles espoused by the majority of the community for the continued improvement of the organization. Bill was elected on a strong platform, actively campaigned by himself and dozens of people who believed in him, promising many positive, needed improvements long desired by the citizens. Both have now repudiated much of what they said, and actually deny they said some of it. Do you see now why I say that truth has no real meaning to them?

This is a long letter, and since I am critical, I should offer some suggestion for improvement. I have this to offer: integrate strong courses in the humanities in the preparatory curricula of all fields of engineering. I say "integrate" because these courses are not isolated from the mainstream of the exact sciences

in any engineering curriculum. Their interrelationships should be fully explored and every effort should be made to help the young students understand this interrelationship.

Consult the professors of political science, sociology, psychology, human relations and like fields, for their thoughts on this integration. Many of the principles of the humanities, like the principles of economics, can be taught within such courses as math and science. By "teaching within" already-required courses, you could reduce the necessity for additional courses in the already-crowded engineering curricula. What I am suggesting is not new. Many industries and businesses are seeing the lack of education in the humanities in their present personnel, and are taking steps to close the gap: A telephone company sends a number of executives back to college to study nothing but literature –a subject which, once understood, can give the student insight into every emotion of man, into man's every need, and which can develop in that student a genuine empathy as he comes to understand other human beings. An engineering firm hires human relations consultants to work with the firm's executives. A large steel company has been sending junior and senior executives to human relations training sessions for several years. On-the-job courses in human relations are given to foremen, to department heads of various business firms; others go to periodic on-campus courses at nearby institutions of higher learning.

Is it not wiser to give these young minds this necessary training along with their technical education, that they may emerge full and *complete* men? Dean Butz has placed his accurate finger on the need to make our students knowledgeable in economics and government; I believe that, hand in hand with that need, goes its inseparable twin, the need to make our students knowledgeable in human relations. Dean Butz' stated weakness in America of "a general indifference to an organized attempt to limit output of worker, factory, and farm" would soon become genuine concern about the attempt and positive action to thwart that attempt–with a generation of fully educated men.

Sincerely yours,
AN EDUCATION EDITOR

P. S. Please do not write off this letter as "just two more instances of 'unkept political promises.'" Neither of these men is a politician in any sense of the word; nor is either of their positions on their communities' groups a "political" position. These positions are important only as they serve to bring out the continuous, total disregard of people which is characteristic of these men.

Defining Humanities

While I quite agree with the sentiment of Baird W. Whitlock's article (April 1960) i.e. that engineers be educated, I would be more than pleased if our friends and allies from non-engineering areas in this endeavor and especially those in 'humanities,' would someday define their areas. This need not be too specific, but it could be in terms of what humanities are. Why are they something separate or special rather than a reasonable 'other area' that students should be introduced to if they are to be educated and not trained only?

Exposure to a wide range of literature, music, art and philosophy is not enough. You can be exposed to those things outside of universities if you wish to be. But to be interested in listening to good music or reading outstanding literature there should be some basis for understanding them. This latter providing a basis for understanding is the university's business, not merely requiring certain reading or listening to and reporting on specific subject matter.

Some of the most helpful ideas about the wholeness of life I obtained from an engineering professor who was himself a member of the American Philosophical Society and who integrated philosophy into his technical courses. I do not believe that one must be freed from departmental restrictions to be able to teach and reveal life in its totality. In fact when anyone is released too completely from certain basic limitations, the free-

dom obtained becomes license. It is dangerous to teach anything as a separate package, because it then takes on the aspects of panacea.

To teach the totality of life with meaning, the teacher himself must be a "total" and a part of the whole. This certainly does not limit the teaching of totality to humanities professors, some of whom, as is the case with some engineers and others, may not be adequate to the task. I have been convinced long since that the philosophy about and the approach to any problem, theory or condition of life is more important than the techniques involved in its solution once the situations are recognized and put into a condition to be solved. Taking a series of observations or experiences and placing them in an array which makes sense, and evolving the problem or problems presented requires understanding of, among other things, philosophy, imagination, social understanding, economics, people reactions and many other things beside the technical understanding in the specific areas in which the experiences were had.

I was intrigued by and here quote from something my secretary, Miss Kathryn Thomas, wrote about the reclamation resettlement experiment we have in Egypt under the title "A Layman Looks at Developing People." "It is a tremendously interesting experience to be a part of an organization that is bringing a new type of activity into existence. How ingenious it is, really, to look around at a completely arid land—or for that matter a lake complete with bull rushes, fish, fishermen, hunters, duck blinds, etc.—and visualize fertile productive lands capable of supporting many thousands of new settlers. This of itself requires considerable vision. . . . However, there is ultimately more than the technical knowhow involved with irrigation and reclamation problems. . . . After these physical aspects comes the singularly more particular problem of the fellahine's (Egyptian farmer) attitude toward what has been accomplished—the new settler's approach to becoming a part of this new experiment."

Need any more be said about the importance of facts, ideas and experiences and an understanding of and ability to put them in their proper perspective when plans are being made for any physical structure, a mass resettlement of people, or the various curricula in our several universities?

Paul F. Keim
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of EARIS, U. S. Operations Mission
to Egypt

NSF GRADUATE FELLOWSHIPS

Applications are now being accepted in two National Science Foundation graduate-level fellowship programs: Cooperative Graduate Fellowships for the academic year 1961–1962, and Summer Fellowships for Graduate Teaching Assistants, for the summer of 1961. Applications for Cooperative Graduate Fellowsips must be received by the participating institutions by November 4, 1960; applications for Summer Fellowships, December 9, 1960.

In both programs, individuals apply through the participating institutions for initial evaluation by local faculty committees, then forwarded to NSF. Panels of scientist-scholars appointed by the National Academy of Sciences-National Research Council perform final evaluation. At both levels of review and evaluation, as well as in the final selection of Fellows by the Foundation, ability is the sole criterion for granting of awards.

The fellowships will be offered for study in the mathematical, physical medical, biological and engineering sciences, including anthropology, psychology (excluding clinical areas), and the social sciences.

Application materials can be obtained from the Graduate Dean of any participating institution or from the Fellowships Section, Division of Scientific Personnel and Education, National Science Foundation, Washington 25, D. C.

General Education in Engineering Curricula: Old Issues and New Developments

COLLECTED PAPERS
of the
1959 ASEE SUMMER SCHOOL

Sponsored by the
English Division and the
Division of Humanities & Social Sciences

Edited by

FRANK R. SMITH
AF Institute of Technology

A
Follow-up
to the
1956 *Report on General Education in Engineering*

FOREWORD

This collection of papers was presented in Pittsburgh at the 1959 ASEE Summer School sponsored jointly by the English Division and the Division of Humanities and Social Sciences. It is unfortunate that the printed words must lose much of the sound and stimulation that filled the large lecture room in the Cathedral of Learning and that none of us had the foresight to try to capture any of the lively discussion that the papers produced.

What remains is nevertheless the core of that Summer School. It includes an assessment of the whole General Education movement by Lewis B. Mayhew, Stephens College, and a historical summary of the development of the humanistic-social stem in engineering education by Edwin S. Burdell, President Emeritus of the Cooper Union. It records an analysis by George Gullette, North Carolina State, of what has happened across the country in engineering schools since the appearance of the famous 1956 *Report on General Education in Engineering*, of which he was one of the principal architects. And it presents well stated cases for flexibility and for integration, two nominally opposed philosophies which have stirred us to debate for years, prepared by Glenn Christensen and Weller Embler.* Finally, recorded here are descriptions of three specific programs which are chiefly the products of the recent fermentation and experimentation.

Every educator interested in creating the best program of general education possible for his student engineers should find these papers interesting and challenging. Even though no one should expect to find ready-made a solution to his special problems, everyone should reasonably expect to profit from learning what his contemporaries have thought and tried since the seminal Report on General Education appeared.

Basically, then, this collection of papers is a statement and analysis of some of the events in general education in Engineering since 1956. It is an interim progress report designed to take a supplementary place beside the 1956 report, but it is obviously not the last word. As these papers show, the general education movement, which really started four or five decades ago, is still gaining momentum—or perhaps *strength* would be a better term, since momentum implies a specific direction, and as yet no single direction of development has appeared.

It was precisely because of this continuing movement and development that the planners of the Summer School felt the need of a pause for report and appraisal. Those planners, whose principal oral deliberation occurred at Newark College of Engineering on 31 October 1958, were the following: Sterling Olmsted, RPI, Chairman; Warren Crater, Newark College of Engineering; George Gullette and Alvin Fountain, North Carolina State; Glenn Christensen, Lehigh; Weller Embler, Cooper Union; Stan Cook, Penn State; and Frank R. Smith, AF Institute of Technology.

A special acknowledgment of gratitude is due Paul Bryant, editor of the JOURNAL, for his patience, consideration, and friendly cooperation in the preparation and publication of these papers. And Secretary W. Leighton Collins has our thanks for his encouragement and for smoothing our access to the funds to help pay for this project.

FRANK R. SMITH

* These papers, "Chow Line or Cafeteria," by Glenn Christensen, Lehigh University, and "The Integrated Program in the Humanities and Social Sciences," by Weller Embler, The Cooper Union, have appeared already in the JOURNAL, the first in March 1960, pp. 572–573, and the second in April 1960, pp. 644–649. Both are included in the separately bound reprint of the collection, which is available for 25¢ a copy from: W. Leighton Collins, Sec., The American Society for Engineering Education, University of Illinois, Urbana, Illinois.

General Education—1959

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Normally a paper on general education begins with a discussion of which particular definition of general education is being considered. Rather than follow such a procedure, this paper will attempt to deal directly with a number of issues on the assumption that the dimensions of general education will be clearly implied.

Before considering some of the developments in general education which have appeared within the last several years, several misconceptions about general education should be corrected. The first of these is that general education is often confused in the minds of faculties of professional schools with the courses offered by university departments of liberal arts and sciences. And this misconception has frequently been facilitated by the liberal arts faculties themselves. Actually the introductory courses in psychology, chemistry, physics, literature, or philosophy are no more general education than is a course in materials testing or general engineering drawing. They are all specialized and typically taught either with a view to a vocational goal or to preparing students for more advanced work in the same field which then leads to vocational skill. It is true that some such courses might, given a master teacher, provide some students with some of the values sought by general education. Such a result, however, is typically accidental and is not one of the primary purposes of the course.

This is not to contend that courses in the colleges of liberal arts are without value. The society needs skilled historians and political scientists as much as it does engineers and doctors. Courses in university colleges of liberal arts and sciences are admirably designed to provide the training such specialists need. Typically, however, they have not provided for the liberal arts or general education needs of students who do not intend to specialize. These have demanded another kind of course. Some of the programs in general education offered at such places as the University of Minnesota or Michigan State were designed to provide these new courses. The fact that liberal arts colleges are often poorly equipped to teach them is demonstrated by the creation of separate divisions of general education at such places as the University of Illinois.

A second misconception is that general or liberal education is simply more theoretical or deeper experience in fields having a direct relevance for specialized fields. It is a fact that specialized faculties in engineering frequently consider mathematics, physics, and chemistry as the most desirable liberal arts courses for their students. Professors in agriculture feel that biology and chemistry are of greatest worth, and professors in business see economics and psychology as being the courses they would like required of their students. Such a view completely misses the point and the nature of general education. If any courses designed for their liberalizing purposes were to be excluded from a professional curriculum, they should be those most like the training emphasized in the specialized field. Thus, if one were faced with the difficult decision of eliminating some general courses from the premedical curriculum, they should probably be those concerned with the biological sciences.

Actually, if general education courses are properly conceived and constructed there would be virtually no over-lap between a general education course in natural science and specialized work in

chemistry, botany, or zoology. The natural science course should have value even for the science major simply because of the broader vision which it allows students to have of science and because at the present time most scientific workers are laymen in all fields of science except the one in which they are working. However, in most specialized curricula, such as engineering, the areas most closely related to the specialty should be the first to be denied students —not the last, as many presently argue.

A third misconception is that general education courses should be judged by the same criteria used in assessing specialized work. A number of general education courses have been criticized because they did not give students a sound mathematical foundation or a thorough grasp of basic chemical theories or a solidly based knowledge of the physiological bases of psychological behavior. A number of critics have sought to eliminate general education because it did not provide the kind of training introductory courses in the discipline provided. General education courses were not intended to replace such introductory courses. They came into being to achieve certain broad objectives which were not being dealt with by any other part of the university curriculum. One could argue that if a general course in social science were doing an adequate job of preparing students directly for abnormal psychology or advanced economics or urban sociology, the course would likely be a failure with respect to its primary mission. A course which tries to develop the facility of all students in dealing with the science materials which all Americans must encounter in their everyday lives does not have time to teach beginning algebra as well. Nor can its teachers side-step their responsibilities merely because many students do not have a good mathematics foundation. There are needs of all men, such as an acquaintanceship with science, an understanding of current society, or an ability to employ leisure effectively, to which specially oriented courses can make a contribution impossible for any other part of the curriculum. These courses should be judged by criteria relevant to their purposes.

A fourth misconception is that general education can be achieved by any well taught course regardless of whether it is in a specialized field or a general one. Examples are mentioned of a course in Old English which was liberalizing for all students, of a chemistry professor who showed students the interrelations of his field and all of human knowledge. And these examples are probably valid. But most teachers lack the ability and interest to do it. Further, even given an inclination in the teacher to relate his specialized work to all of human knowledge—to do so extensively may be a disservice to the specialized course. The professor of the course in building design might well concentrate his efforts in providing first-rate training in design instead of trying to do that and provide his students with a general education as well.

This is a dangerous doctrine and one susceptible of being misunderstood. For there are teachers who can accomplish both the specialized goals of their courses and a liberalizing function as well. Further, there are students whose minds can make the leap from the practical problems of diet control in a Home Economics course to broader concerns of all people. These should not be proscribed. However, it should be accepted that most of us are not so gifted that we can accomplish two major educational tasks at the same time. Courses in general education are devices by which the normal range of professors can teach the normal range of students some of those facts, principles, methods, and appreciations which are needed by all men.

A last misconception is that general education is a luxury which can be injected into the curriculum if there happens to be room. If the requirements of the American Chemical Society have been met and students have a few hours of electives left, it won't hurt them to take a course in World Literature. The point should be emphasized that either general education has sufficient intrinsic value to command a respected place in a specialized curriculum or it has no value. If it is something which can be

taken or left alone without significant results one way or another, it should be cut out of the curriculum.

Actually the needs which general education seeks to meet are the most crucial ones modern man has. The death toll on American highways is not the result of lack of technical skills to make roads and cars or to use them. Rather it results from those qualities in men's minds which are the direct concern of courses in personal adjustment. The growing incidence of excessive use of alcohol or narcotics is not caused by lack of specialized skill in producing or understanding such materials. Rather it seems to result from the poverty in men's lives which courses in the humanities seek to alleviate. The inhumanity of much of contemporary architecture or city planning is not the result of lack of technical design skills. Rather it is because men forget they are men—a matter which courses in social science seek to remedy.

These misconceptions should be corrected, and there are hopeful signs that this is happening. As general education has come of age as a serious educational movement and more and more colleges and universities have decided to experiment with it, this rectification of faculty impression has taken place. It can also take place as general education as a movement moves into new areas and attempts to solve new problems. Some of these new concerns have already become apparent—a few as recently as within the past year. In the past, general education in its most characteristic forms has been concentrated in the first two years of college. In the thirteenth and fourteenth grades, students were asked or required to take courses in social science, communication, natural sciences, or humanities. By the junior collegiate year students had begun to concentrate and had finished their basic or general requirements. Some colleges, however, experimented with a senior integrating course of some sort and found such offerings valuable parts of the general curriculum. Then, too, students frequently reported that they were more ready in their senior year for interdepartmental courses than they had been as freshman or sophomores. Such factors gradually have led to a significant modification of the time during the undergraduate program when general education can be offered. Sometimes this is a creeping change, as when many junior and senior curricula at Michigan State began to include the sophomore course in the humanities. Sometimes it is accomplished by deliberately planning general education courses for all four years.

In all candor it should be mentioned that concentration of the general courses in the first two collegiate years is still most typical. However, a growing number of professors believe that spreading requirements over four years is a proper and desirable change.

A second development has been an intensified concern with student values. General education objectives have always claimed concern for students' attitudes, values, and personal adjustment. However, with the publication of the Jacob report on student values and the sudden concern with student conformity, it was realized that the value goals had not been achieved. If one analyzes educational conferences held within the past several years, one is struck by the frequency of discussions of how to teach values. Next to the financing of higher education and the conditions of faculty service, the sections on values at the 14th Annual Conference on Higher Education were the best attended.

This concern has not resulted in definite solutions to the problem. It has not even resulted in a clear delineation of the matter. For example, the Association for Higher Education sponsored a conference on the teaching of values in the summer of 1958. Participants all were associated with courses giving explicit attention to values. The conference conclusion was that values are important and should be attacked throughout the curriculum. However, no one as yet knows how to do it. The conference participants wished they did.

A third development is related to the post-Sputnik demands for greater intellectual rigor in collegiate courses. This nationwide plea has resulted frequently in efforts to return the collegiate cur-

riculum to an earlier form which concentrates on courses within each of the more traditional academic departments. This has caused a feeling of defensiveness on the part of many who are active in general education. It has also caused the abolition of a number of the more experimental efforts which promised a healthy change.

A fourth current characteristic is the fact that general education as a movement has become static. General education came into existence as a protest against the free elective system, proliferation of courses, poor teaching, and an unconcern about interrelationships among areas of knowledge. It gained its force from this protest. Many of the chief documents in the history of general education, such as the statements of Robert M. Hutchens, The Harvard Report, or the Report of President Truman's Commission on Higher Education, are most eloquent in criticizing previous forms of education and their failures. Once some of the principal ideas of the movement gained wide acceptance, there was need for a more positive dynamic if general education as an intellectual movement were to be kept alive. Such a dynamic has not been identified by any appreciable number of spokesmen. Thus general education in 1959 is in a state of transition as it seeks for new dragons to slay. The situation, however, is not too bleak because there are several other facets which have appeared recently which may provide the needed spirit of advance.

One of these, and a fifth characteristic, is linked to the emergence of junior or community colleges. This is a development much discussed but little understood in its full magnitude. The junior colleges in a few states are now educating over half of the students in the 13th and 14th grades who are attending tax-supported institutions. Further, this pattern is spreading to other states and will continue to spread. At this time one can predict that the collegiate education of the future in the freshman and sophomore years will typically be non-residential education provided either by two-year institutions or by special programs which resemble junior colleges within four-year institutions. The latter will, of course, continue to be residential colleges, but the majority of students will gain their first collegiate education while they continue to live at home.

The significance here of the emergence of junior colleges is that typically they are adopting programs of general education as the core of their programs on the assumption that all students, regardless of whether terminal, technical, or looking to further training, should have such experiences. The logic of development is thus clear. Junior colleges will educate the majority of college-age youth. This education will consist basically of general education. General education thus becomes the kind experienced by most college-trained people in the country. Numbers alone will make it significant and worthy of further refinement.

Another facet is related to the growing national awareness of the significance of non-occidental peoples and culture. Early programs of general education were restricted to western European and American culture. A humanities course, for example, might be based on western civilization from the Greeks to the Surrealists and its companion social science course would focus on problems of American democracy. The methods taught in the biological or physical science courses were those of western empirical science. Selections used in communication courses to teach reading usually grew out of this same western tradition. Even theorists about education argued that this preoccupation with the West was wise. The late Gordon Chalmers, for example, argued that elements of non-occidental culture should be included in the curriculum only if they corroborated or reinforced important strands in western ideology.

Thoughtful Americans have suddenly discovered that the East is bound to be of increasing significance in their lives, not only because of the struggle with Russia but because of the growing population force of once-subject peoples of the Far East. Consequently, there is a real effort to include oriental elements in some general education programs. The University of Chicago and Columbia Col-

lege have initiated non-occidental courses in their humanities sequences. Michigan State is trying to adapt its social science course so that the examples studied with tools of social science will include oriental ones. One conference on the role of non-occidental culture in general education has already been held. Even in courses dealing with the nature of thought and of religious experience, oriental approaches are beginning to be considered.

Another development derives from the growing attention to the education of the gifted. Efforts to provide for the most able students have consisted of enriched courses, honors work, independent study, and to a lesser extent acceleration. As some of these have proven of value for students of high academic ability, several people have attempted to use the same devices with students in the middle ability ranges. At least one source for the idea of a senior colloquium required of all students has been the success of such activities for highly capable students. In Ohio eight colleges conducted a three-year study of education for the gifted. The most significant outcome was the insight that perhaps the whole collegiate program could be improved through use of the same techniques. Dr. Thomas H. Hamilton, former vice president of Michigan State University, established the Honors College at Michigan State partly to suggest how the entire undergraduate general education curriculum could be reformed. Bonthius and others report on the increasing number of independent study programs found in the country and how those which are open to all students were first attempted with the very able students.

Allied with this is the fact, of relevance particularly for general education, that customary ways of grouping students by academic ability are being challenged. Wilbur Brookover, a social psychologist, argues in a recent issue of *School and Society* that superior academic achievement is more the product of the perceived expectations of others than of any innate qualities. He reasons that there is no difference in the complexity of the skills of reading and those of speaking. Yet every one, save a very few seriously handicapped, learns to speak simply because everyone is expected to speak. If college students of the normal range of ability are expected to do independent work of honors level and if they perceive that teachers and parents are honest in these expectations, they will do the work and profit from it.

Another important development is the possible change in relationship between colleges and universities and the social institutions of business, labor, industry, the armed forces, and other employing groups. In the past these institutions have relied upon the school to provide students with considerable vocational training. This reliance resulted in the large schools of engineering, business, and the like which offer highly practical programs to fit students for definite jobs. There is some evidence that this situation is changing, that business, industry, and to a lesser extent the armed forces are willing to provide the practical training needed for jobs. One senses the spirit of this in the pleas of corporation presidents for liberally educated people who can profit from on-the-job training. One gains concrete evidence by observing the expanding number of institutes sponsored by corporations and watching the intensive training programs to which new employees are subjected.

As some of the responsibility for technical education is assumed by institutions other than the school, colleges and universities may find more time to devote to general education. Since this phase of the development is in the future, little definite information can be produced. Illustrative, however, is the trend in the occupation division at Stephens College to shorten the time students spend on vocational courses and thus to allow more time for general education courses.

A last factor from the contemporary scene which should be mentioned is the fact that a body of theory and evidence about general education has been tested over two decades of development. The substance of these experiences can be brought together rather quickly to serve as a guide for any institution embarking upon a program of general education.

In fact Harper and Brothers published *General Education: An Account and Appraisal* in the fall of 1959; it presents just such a collection of theory and practice. The newly formed University of South Florida, which will open in the fall of 1960, will start with a fully developed program of general education. There is nothing particularly new in any aspect of the program. Rather, the administration of that institution has simply worked the existing knowledge into a new program. Similarly, the experimental colleges being started by Wayne State University, Hofstra College, and the four institutions in Amherst, Massachusetts, have all gone to the body of tested general education practice for the substance of their new programs. In this respect, then, one can conclude that general education has come of age.

Other trends could be mentioned but these were selected because of their broad significance and because of their relevance for specialized education. For out of the emergence of general education come some rather clear implications for all of the collegiate enterprise.

Perhaps the most important implications from the maturation of general education are some broad principles for technical education. It has been established that facts and principles from a variety of disciplines can be combined into curricular offerings which provide students with a broad base from which they can move to later specialization. Students taking such broad courses before actually deciding on a field of specialization are inclined to make a more permanent choice, to make better grades, and to like their final choice better than are students who start to specialize as soon as they enter college. Something in the chance to see inter-disciplinary relationships seems of value to students. With this in mind one can argue that much of the early work in specialized fields could be more broadly conceived. Thus in place of asking students to take specialized work in electronics or materials testing and the like, they might be asked to take theoretical courses in physics, and then broad courses on engineering principles. Only in the senior year and perhaps not until graduate school or on the job would engineers begin to specialize in a particular kind of engineering. General education courses have shown the way for interdisciplinary effort. Specialized education can adapt these procedures in many different ways.

A second implication is the clear fact that in the future, universities to which engineering and other specialized schools are attached will not have control over the first two years of their graduates' education. As junior colleges multiply, more students will attend them and then transfer to four-year institutions. Universities, particularly state-supported ones, will not be allowed to reject many of these students simply because the pattern of the freshmen and sophomore years differs from what specialized faculties would like. Public opinion will simply not allow it. And since these junior colleges are emphasizing general education, specialized schools will be forced to accommodate their programs to the outcomes of general education. This condition will make for friction. Specialized faculties are jealous of the time students spend in non-technical courses. Yet they will find themselves in a situation in which students do spend much time in non-specialized work. They may try to remedy this by starting the program leading to the bachelor's degree at the junior year, thus insisting that all transfer students will take at least five years and an appreciable number six years for their first technical degree. This, in my judgment, will be a shortsighted policy. More appropriate would be close cooperation between technical faculties and junior colleges, each modifying its program so that neither students nor society will be penalized with an excessively costly educational plan.

An allied implication is that specialized faculties must learn more about general education if they are to work cooperatively with faculties offering general courses. Many technical professors say they know nothing and care even less about general or liberal education. And within this category are included the specialized fields of the liberal arts college as well as engineering, agriculture, and

the like. Should this attitude prevail, the same sort of cleavage which grew up between the arts and the education faculties will develop between the junior college and the university faculties. Out of such conflict no good can come. A more healthy situation would be one in which technical faculties and those offering general education, whether on the same campus or at different institutions, would search constantly to understand each other and to accommodate differences so that the real education of students can prosper. This point needs to be made explicit. A large proportion of technical faculty members see no great value in courses dealing with philosophy and values. Yet these are important concerns to general education. Many general education people are skeptical about a course in plant management taught in the engineering school, for example, yet engineering professors can make a strong case for such a course. Such differences have to be compromised if students are to hope to finish their formal education in a reasonable time.

Such are some trends and conditions of general education in 1959. As to the future, general education can progress as a dynamic movement if the people in it will it to do so. There will be obstacles of the current social scene, of vested academic interest, and the like. But if those of us interested in this nonvocational part of education will ponder what we have learned in the past and not minimize the violent things happening in contemporary society, some of these significant trends can be fully realized.

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The General Education Movement:

From the Wickenden Report to the Report on General Education in Engineering

EDWIN S. BURDELL
President
The Cooper Union *

Most appropriate it is that this 1959 ASEE Summer School in Pittsburgh, sponsored by the Humanistic-Social and English Divisions, on the broad theme of "General Education in Engineering Curricula—Old Issues and New Developments," considers the Wickenden Report at its opening session. For the idea of the ASEE Summer School was broached by William E. Wickenden himself, the Director of Investigations of the Society for the Promotion of Engineering Education from 1923 to 1929, as one result of his comparative study of engineering education in the United States and in Europe.

It is also appropriate to recall that the Director of Summer Schools for the SPEE from 1927 to 1933 was none other than a professor of civil engineering at Brooklyn Polytechnic Institute named H. P. Hammond, who was associate director of investigations from 1923 to 1929, and who later as Dean of the School of Engineering at Pennsylvania State College was to have his name forever substituted for the title of the 1940 Report of the Committee on Aims and Scope of Engineering Curricula; it is now known to all of us as the Hammond Report.[1]

Summer sessions were held annually throughout the country, each devoted to a particular field: engineering mechanics in 1927; physics and electrical engineering in 1928; mechanical engineering in 1929; engineering drawing and civil engineering in 1930; chemical engineering and mathematics in 1931; economics and English in 1932; and mining and metallurgical engineering in 1933. Chairman Hammond took pride that this system of rotation considered "all of the important divisions of engineering study," [2] and we may take reassurance from the fact that in 1933 he included economics and English in the important divisions of engineering study.

The Wickenden Report tells us, incidentally, that the 1932 English Summer School was held at the Ohio State University, with 62 teachers in attendance, representing 29 colleges. The JOURNAL OF ENGINEERING EDUCATION for the following November, December, January, and February contains papers under the following headings:

English in Engineering Education
Problems of Administering English Work in Engineering Colleges
Technical Exposition for the General Reader
What Does the Configurationist Say?
The Young Engineer and His English
The Art of Technical Writing

The first volume of the Wickenden Report concluded in 1929 that

> Two auspicious things have occurred . . . The Society has undertaken to continue the Summer Schools for Engineering Teachers which were proposed and inaugurated by the Board, thus putting into prac-

* In collaboration with Professor Richard S. Bowman, Associate Professor of Comparative Literature.

[1] Hammond, H. P., Chairman, "Report of Committee on Aims and Scope of Engineering Curricula," *Journal of Engineering Education*, New Series Vol. XXX, No. 7, March 1940, pp. 555–566.

[2] Wickenden, W. E., *Report of the Investigation of Engineering Education, 1923-29*. Pittsburgh: Society for the Promotion of Engineering Education, 1930 (Vol. I), 1934 (Vol. II), pp. 1118, 1121.

tical operation an affective [sic] means of developing engineering teachers, which is the key to the problem of developing engineering education.[3]

And the second volume added in 1934 that

> Of all the many ways in which it was found that engineering education might be made better, the outstanding one was better teachers. Whatever might be done in the future to select and develop teachers there was the immediate problem. How can the quality of present teachers be improved? In a previous section it is recorded that many faculties considered training in the methods of teaching as desirable, but questioned its practicability. Happily a plan of teacher development was evolved and put into effect on a scale large enough to produce useful results and also to indicate the desirability of continuance.
>
> The Summer School project brought together teachers in a particular subject for a three-weeks' session in which they might qualify as better teachers.[4]

I hope that this concentration on the summer school aspect of the Wickenden Report has given you not only an idea of the special importance of the summer school in engineering education, but also some inkling of the comprehensiveness of that gigantic Wickenden Report, with its 1,603 pages, including several hundred tables and charts. (Indeed, the Wickenden Report reminds one at times of the mechanization of human emotions in the Kinsey Report, where love becomes a frequency of outlet.) But it is merely one in a series of extended studies of engineering education, and thus, if I am to speak of old issues in the reports on general education in engineering, it is necessary for me to point out how much older than the Wickenden Report these issues are.

As I scan the whole terrain from the founding of RPI in 1824 to the Report on General Education in 1956, I note four main themes:

(1) A skepticism about the discrepancy between what is said and what is done in engineering education;

(2) The influence of war on nearly all developments and investigations of engineering education;

(3) The role of the technical institute and its relations to professional engineering education; still left for the future are proofs that the technical institutes do not have to be devoid of the humanities—that they are, instead, terminal education, and should provide an introduction to citizenship;

(4) The continuum of interest in engineering education, the evidence that the concern has gone on; although performance may ignore it, it is important to realize the persistence, the leavening of this concern; education is a continuum, not a dichotomy.

Engineering educators deserve great credit for taking the initiative in self-investigation. In 1893, engineering educators from all institutions and all fields of study had united in the Society for the Promotion of Engineering Education, and it was not long before they began the first of a series of internal surveys and analyses.

In contrast to engineering education's initiative, the medical and legal professional schools were investigated at the initiative of the Carnegie Foundation, in the famous Flexner reports of 1910 and 1912, and the Redlich report of 1914. A caveat must be pronounced, however, lest we seem to make invidious distinctions between education for engineering and that for other professions. Medicine and law as professions grew out of the apprenticeship system: the profession existed before the professional school. When the practitioners organized their classes of apprentices into schools, these schools belonged much more to the profession than to the university to which they were appended.

Engineering education, on the other hand, was created before the engineering profession gained status. The engineering school was founded as an outgrowth of the college, to supply, as William B. Rogers expressed it in his plans for M.I.T. in 1861, "the intellectual element in production" by imparting knowledge of natural science. As the 19th century

[3] Wickenden I, p. 13.
[4] Wickenden II, p. 1260.

technological revolution proceeded, the gap widened between engineering education and new industrial demands. Consequently, it was a significant step when President Dugald C. Jackson at the 1907 Cleveland meeting of SPEE invited the professional societies of civil, mining, mechanical, and electrical engineering and the American Chemical Society to appoint two delegates each to a Joint Committee on Engineering Education, on which SPEE itself would have only three members.

The duty of this committee was to examine into all branches of engineering education, including engineering research, graduate professional courses, undergraduate engineering instruction, and the proper relations of engineering schools to the secondary industrial schools or foreman's schools, and to formulate a report or reports upon the appropriate scope of engineering education and the degree of cooperation and unity that may be advantageously arranged between the various engineering schools.[5]

This 1907 resolution begins with a great WHEREAS, which has been the spiritual WHEREAS of half a century of investigation into engineering education:

"WHEREAS, it is desirable to make a comprehensive study of the objects and the utilities and the correct ideals of engineering education. . . ."

The recurrent concern with the technical institute which I have mentioned was epitomized by the subject of Dugald Jackson's presidential address at the annual dinner: "The Relations of the Engineering Schools to Polytechnic Industrial Education." [6]

Discussion of Dugald Jackson's paper produced one comment which we might classify as alarming, prophetic, optimistic, or smug. Dean Woodward of Washington University, St. Louis, told it to climax a story:

We do not believe that it is blasphemous to attempt to improve the face of the earth and the facilities for transportation. A couple of hundred years ago in Spain, two engineers proposed to an ecclesiastical council to improve the navigation of two rivers. They said, 'If you will give us the opportunity and the liberty, we can improve the navigation of these rivers so they will be more serviceable.' The ecclesiastical body thought it over and finally decided that 'if it had been the wish of the Almighty that these rivers should be navigable, He would have made them navigable without the help of human hands; as He did not do so, evidently He did not wish them to be navigable.' So the improvement was forbidden. We believe that the earth is put into our hands ready to be finished.[7]

In 1959, one reads quite differently from the audience of 1907, that statement: "We believe that the earth is put into our hands ready to be finished."

In 1908 the Carnegie Foundation and the General Education Board were invited to appoint delegates to the Joint Committee on Engineering Education. By 1914 the Committee had gathered a considerable amount of material bearing on the subject, but needed help. The Carnegie Foundation agreed to bear the expense, and appointed Dr. Charles Riborg Mann to work full time to complete the investigation and report. Dr. Mann was formerly associate professor of physics in the University of Chicago, then chairman of the advisory board to the War Department Committee on Education. The Mann report of 1918 was thus the result of SPEE efforts, aided by the engineering societies, from 1907 to 1914, and of united efforts with the Carnegie Foundation from 1915 to 1918.

Undoubtedly, the Mann Report benefited from the fact that the Flexner report on medical education had breached the academic walls eight years before and opened up the academic community to sharp criticism from outside. This is not to say that engineering education was in the appalling state in which Flexner found medical education, but technical schools of engineering and the mechanic arts, stated Flexner, afforded an illuminating comparison.

These institutions began, like the college, at a low level; but they did not long rest

[5] Society for the Promotion of Engineering Education. *Proceedings of the Fifteenth Annual Meeting* held in Cleveland, Ohio, Vol. XV. Brooklyn, N. Y., Office of the Secretary, Pratt Institute, 1907, pp. 17–18.

[6] *Ibid.*, pp. 363–377.

[7] *Ibid.*, p. 380.

there. To their graduates, tasks involving human life and welfare were committed: the building of bridges; the installation of power plants; the construction of sewage systems. The technical school was thus driven to seek students of greater maturity, of more thorough preliminary schooling, and strictly to confine its opportunities to them.[8]

In 1959 we of engineering education need to lift our sights, to merit again such favorable comparison with medical education as we received half a century ago.

What I have tried to demonstrate thus far in my talk is that when we convene here in Pittsburgh for these two days to investigate general education in engineering curricula, we are the inheritors of and partakers in a spirit of self-investigation which has peculiarly animated engineering education throughout the twentieth century. It comes more naturally to us than we perhaps realized to question our objects and utilities and correct ideals, and to see the parts in relation to the whole.

I have spent this long on early material because it has seemed to me that my rôle in your program is to help us establish our roots deeply. Without entering into the many other interesting aspects of the various investigation reports, let me now trace briefly the rôle of general studies in them.

First, the Mann Report of 1918: "A Study of Engineering Education." How many of you realize that when engineering schools were first founded their curricula included more general studies than we now aspire to in our 1940, 1944, and 1956 reports? The ME curriculum at MIT in 1867 measured 31% humanities, but by 1914 had dropped to 18%. The average for 26 engineering schools was 27% humanities in 1867; 19% in 1914.[9]

[8] Flexner, Abraham, *Medical Education in the United States and Canada.* Bulletin Number 4. New York: Carnegie Foundation for the Advancement of Teaching, 1910, pp. 22, 23.

[9] Mann, Charles Riborg, *A Study of Engineering Education.* Prepared for the Joint Committee on Engineering Education of the National Engineering Societies. Bulletin Number 11. New York: Carnegie Foundation for the Advancement of Teaching, 1918, p. 22.

The curriculum had become "congested beyond endurance" as the choice of curricula expanded from the original 3 to 24, and the professional specialties from 4 to 40.[10] This congestion had obviously squeezed the humanities.

Against such congestion, the Mann Report took arms. To accomplish this curriculum in a total of 50 hours for class and preparation per week, the student had precisely 3 hours, 50 minutes, 46.15 seconds per week for each of 13 courses.[11] But what are the most important factors in determining probable success or failure in engineering? Mann asked 30,000 members of the four large engineering societies to number six groups of qualities headed respectively Character, Judgment, Efficiency, Understanding of Men, Knowledge, and Technique, in the order of importance which they gave them in judging the reasons for engineering success and in sizing up young men for employment or for promotion. Seven thousand engineers replied: 94.5% of them put Character at the top and Technique at the bottom.[12]

How have we expressed this belief in practice? I suppose some of the reluctance to do anything about it rests unconsciously on Woodrow Wilson's observation that the man who sets about to achieve "character" makes himself ridiculous; that character is the by-product of a quest for other goals.

Whatever the goals of either education or industry, Mann found no correlation between high grades in college and the ability of several hundred engineering graduates to meet the requirements of the General Electric and Westinghouse Companies.[13]

He found that student mortality in the engineering schools had been reduced from 90% in the early years to 60% in 1917 (by mortality he meant inability to complete the course in 4 years). He insisted that many of these students are sent away from the engineering school without any fair test of their capacity for engineering practice or study. His solu-

[10] Mann, p. 27.
[11] Mann, p. 25.
[12] Mann, pp. 106–107.
[13] Mann, p. 36.

tion was to do away with the division of engineering education into two years of preliminary science and two years of engineering applications, a system taken over in 1849 from the École Polytechnique. Interrelate theory and practice, the abstract and the concrete, throughout the college course, he said. Reduce the subjects to 5 at a time. Increase the use and vitality of each course by showing its commercial bearings, the controlling power of costs.

Mann frankly recognized the "obviously serious danger of actually becoming too materialistic, thereby sacrificing powers of abstract thought and humanistic ideals on which real progress ultimately depends. Efficiency in the mastery of materials without humane intelligence to guide and control it is now recognized in all civilized countries as a curse." Right here, Mann urged, was the opportunity for the humanistic studies to counteract this mechanical and materialistic bias. He praised an English course developed at MIT by Frank Aydelotte, in which the students began with discussions about the nature of a profession and of engineering, and went on to readings by scientists like Huxley and Tyndall, then to works of literary men like Arnold, Newman, Carlyle and Ruskin.[14]

Mann found widespread agreement among professional engineers "that considerable attention should be paid to humanistic studies like English, Economics, Sociology, and History, not merely because of their practical value to the engineer, but also because of their broad human values."[15]

I have devoted this much time to the Mann Report because a very great deal that we have said in our 1930, 1934, 1940, and 1956 reports about the value of the humanities was already established theory in that cogent and readable report of 1918. He found then the lack of inherent connection which still troubles us today:

> The sciences are usually treated as sciences pure and simple without regard to their function in engineering; in the mechanical arts the instruction shops are as a rule purposely separated from the construction shops; and the humanities generally strive consciously and vigorously to get away from engineering in order that the student may get at least a glimpse into the mysteries of language and of literature and a touch of culture.[16]

He insisted that "humanistic work becomes significant, and therefore educative, when it starts from and builds upon the professional interest."[17] I do not think we have accepted that suggestion. The 1944 report, for example, emphasized the need to discriminate between humanistic studies and business training, and placed upon engineering faculties the duty of developing professional consciousness among engineering students.

Three final points made by the Mann report are relevant to our consideration of general education today:

> (1) No amount of drill in the technique of language will make a student write and speak clearly if he does not think clearly; and training in clear thinking is as much the function of teachers of science, mathematics, and engineering as it is the function of the teachers of English.
>
> (2) If the professors in the technical subjects rigidly exclude from their instruction all discussion of human values and costs, is it reasonable to expect the students to appreciate economics and social science?
>
> (3) Discard the usual method of teaching humanistic subjects in short independent courses in the technique of composition, literature, history, economics, and so on. Extend this work into a "consecutive" course extending through the entire curriculum and consisting of live discussions and extensive study of the best that has been thought and said concerning the immediate and the ultimate values in life.[18]

I am sure you understand now why a principal point of my talk is an expression of skepticism about the discrepancy between what is said and what is done in engineering education. How much further along we would be toward achieving the goals of general education, had we begun in 1918 to implement the recommendations of the Mann Report.

[14] Mann, pp. 63–64.
[15] Mann, p. 88.
[16] Mann, p. 90.
[17] Mann, p. 93.
[18] Mann, pp. 92, 93, 99.

instead of piling report upon report! Perhaps the main service of all these subsequent reports has been to gather increased support for these objectives, and to etch out more precisely their applications. Indeed, the Mann Report has gathered moss, and the reports have rolled on, stone after stone.

The Wickenden report represented a step backward for the humanities. The index covers ten years of investigation, from 1923 to 1933, published in two volumes containing a total of 1,603 pages. I cannot claim to have reread every page, but I have looked up every reference to English and the humanities. The most heartening material about the 1932 Summer School in English I have already given you. Of the ten references to English, eight of them are tabulations of aptitude, entrance, and graduation requirements. The other two are responses of graduates to questionnaires: electrical engineering graduates assigned an importance to English second only to the fundamental sciences; [19] the most significant suggestions of technical institute graduates were for more and, as some of them expressed it, better instruction in English.[20]

The sole reference to Humanistic Studies is to one long paragraph—shall we call it 1/2,000th of the report? [21] The primary criterion in the choice of humanistic studies is to be functional relation to engineering, not intrinsic cultural or intellectual values.

An admirable list of subjects is proposed as integral elements in engineering education (not preliminaries or addenda):

- English studies, both for facility of expression in speech and writing and for acquaintance with literature
- Studies which deal with the evolution and present state of social processes and institutions
- Studies in human nature and conduct
- Studies in economics both social and technical
- Modern language for tool and colloquial uses

[19] Wickenden, I, p. 380.

[20] Wickenden, II, p. 106 (Technical Institutes, A Study of).

[21] Wickenden, I, pp. 148–149.

But this whole program collapses in the following sentence: "We recognize, however, that it is not practicable to provide instruction in all of these branches for all students." Engineers are, if anything, practical men, and we can trust them to recognize that sentence for what it is.

What the recommendation boils down to is to include English and economics in all curricula. Even here there is a leak in the pot, in the provision: "unless the levels of preparatory education are exceptional."

We can find solace in one recommendation which I am sure we would still like to see adopted:

> We favor an unremitting insistence on clearness and accuracy of expression in all work, written or spoken, performed by engineering students, and think it proper for the colleges to deny graduation to students whose daily work does not bespeak a relatively high standard of literacy.

It is too late, however, for the report's admission that "the lack of acquaintance with historical backgrounds is a handicap to the progress of the technical professions; we therefore commend to our colleges a more general study and teaching of science and technics as moulding forces in civilization."

For the choice of other humanistic studies, besides English and economics, is to be governed by local conditions, special needs, and functional relation to engineering pursuits. "If a margin of time remains after this criterion has been fully met, we favor keeping it free for studies having purely cultural aims."

I have been engaged in engineering education for 25 years, since 1934, and I am still looking for a margin of time. That concludes my remarks on the Wickenden Report in relation to engineering education.

Obviously, the movement for general studies had to start all over again from its position before the Mann Report. Fortunately, two stimuli came to its aid. The unendurable congestion of the curriculum which Mann had pointed out was now provoking a movement to extend the undergraduate curricula to 5 or 6 years. Another discussion was under

way about the desirability of requiring preliminary study in schools of liberal arts before admission to the engineering school. Any profession which could digest the Wickenden Report could clearly tolerate a great deal of discussion, but this time discussion burst the dam: someone introduced a bill in the Legislature of New York giving credit to candidates for professional licensure for courses taken in preliminary liberal arts courses.

In June 1939 the SPEE appointed Dean Hammond Chairman of the Committee on Aims and Scope of Engineering Curricula and I was among the 12 persons appointed to it—and am among the few of that group still living and active in engineering education. In March 1940 its report appeared: 9 months to write it, instead of the Wickenden Report's 10 years; 11 refreshingly short pages, to the Wickenden's 1,603. We all know the content of this report, since its objectives were endorsed by the 1944 report, and the practical difficulties of understanding and implementing them were investigated most helpfully by the 1956 report.[22]

The Hammond report answered the question which provoked it by holding the line on the 4-year undergraduate curricula. It did so by recommending that some advanced technical subject matter be transferred to the postgraduate period, by relegating to other institutions briefer, more directly practical forms of technological education, by asking that the use of the student's time be pruned to the essentials of a sound educational program, and by requiring efficiency (a purr-word, as Hayakawa would put it) of engineers. In this case, efficiency was defined to mean: reduction of total content of subject matter; concentration on fewer courses; minimizing purely descriptive material and repetitive tasks; abandonment of effort to develop the specialized skills now emphasized.

I mention all these specific means of maintaining the curricula at 4 years because it would have been so easy for the Hammond Committee to acquit its task by simply eliminating the remaining courses in general education. On the contrary, the report recommended that "Undergraduate curricula should be made broader and more fundamental through increased emphasis on basic sciences and humanistic and social studies." To this end it divided the undergraduate curriculum into two stems, the scientific-technological and the humanistic-social. Each of these stems was to be organized in an articulated sequence of subject matter, the goals of which were defined in terms of the competences which students should acquire. The report concluded that there are advantages in the parallel development of these two stems, and that the present integrated program extending throughout the entire four years should be preserved.

Basic to the Hammond Report is the recognition that in a technological civilization, the engineer must take part in the solution of many of its social problems. To that end, his professional status must be enhanced, and he must function more vitally, both technically and administratively, in industry and government. The roots of his education must extend more deeply into the social sciences and humanities as well as into professional life.

In 1934 when President Compton called me to MIT to head up its first division of humanities, that innovation was a revolutionary step. Since then this division has expanded into a whole School of Humanities, giving its own doctoral degree. But such a happy development might have been frustrated. World War II might have permanently mutilated the general studies, as engineering education trimmed its curricula to the bare attainment of the specific technical objectives of war industry and the military, literally reversing the process embodied in the recommendations of the Hammond report. It is greatly to the honor of our profession that in May 1944, a year and a half before the end of the war, we could publish a report on Engineering Education After the War

[22] *General Education in Engineering*, A Report of the Humanistic-Social Research Project. Urbana, Illinois: The American Society for Engineering Education, 1956 (also *Journal of Engineering Education*, Vol. 46, No. 8, April, 1956, pp. 619–750.

which stated boldly: "The directives of the 1940 Report on Aims and Scope of Engineering Curricula remain essentially valid." It called for only one major extension: "a more positive indoctrination in civic and professional responsibilities." [23]

From 1946 to 1949, succeeding Dean Hammond, I served as Chairman of the Humanistic-Social Division of the ASEE.

[23] Hammond, H. P., Chairman, "Report of Committee on Engineering Education After the War," *Journal of Engineering Education*, Vol. XXXIV, No. 9, May, 1944, pp. 589–613.

Many a request came to me from engineering deans around the country for a ready-made humanities program. I had always to reply that such a program must be tailor-made, jointly by local engineering and arts faculties, to fit local conditions. It goes without saying, then, that I applaud George Gullette and his entire hardworking team for preserving this emphasis in their 1956 report on General Education in Engineering. I was honored to serve as its chairman. But to comment further on that report would be to trespass at both ends of my paper beyond the limits assigned me.

INDUSTRIAL ENGINEERING AT NEWARK

Newark College of Engineering began a program in September to grant the degree of Bachelor of Science in Industrial Engineering.

The college has been offering the Master of Science degree in the related field of Managament Engineering since 1946. The new degree brings to five the number of fields in which both the B.S. and M.S. are offered. The others are Chemical, Civil, Electrical and Mechanical engineering.

NEW PH.D. PROGRAM AT WAYNE STATE

Effective with the recent approval by the Wayne State University Board of Governors, the Graduate Program of the Engineering Mechanics Department is currently being expanded to include the doctoral level.

Graduate students who complete the course and dissertation requirement will become eligible for the degree of Doctor of Philosophy in Engineering Mechanics.

Since the Report on General Education in Engineering

GEORGE A. GULLETTE

Head, Department of Social Studies
North Carolina State College

First, I want you to know that the report I am about to give is based upon evidence from the perfect questionnaire—one that was never sent. It came about this way. When a group of us met last fall in Newark to plan these meetings, it was agreed that we needed some factual data concerning what has happened to the humanities and social sciences in engineering curricula since the publication of our report three years ago. It was agreed that we should send a questionnaire to all engineering schools soliciting the relevant information. We were made aware that the General Council of this Society has been taking an extremely dim view of questionnaires, and has ruled that none are to be circulated without the express permission of Secretary Collins. Sympathetic to the motives behind this ruling, we spent some time in working out what we thought was a very clear and simple questionnaire that would get the information we needed with a minimum of trouble to harried heads of departments and deans. But Secretary Collins did not share our enthusiasm for our own handiwork, and it was only after weeks of maneuvering and even some pressuring that we wrung from him reluctant consent to try our masterpiece on only eight deans who were then to report to Secretary Collins what they thought of it.

It was at this juncture that someone, I think it was Dr. Olmsted, remembered that Dean Grinter had just completed a followup study of his report on *Evaluation of Engineering Education* and had apparently included in it a question about the humanities work. With a minimum of difficulty we received permission to examine the raw material from Dean Grinter's study, and discovered, to our great joy and to Secretary Collins' great relief, that it contained almost exactly what we needed. So we did not have to bother even eight deans.

I want to thank Secretary Collins for protecting the engineering deans of the country from a questionnaire that clearly would have duplicated one they had just struggled with, and I want to thank Dean Grinter for making the materials available to us. Dean Grinter has, of course, published his findings in the March 1959 issue of the JOURNAL, but I hope here to be able to add some detail to his necessarily general statements. I remind you that of course the data I am reporting on is now a year old. However, one of the most encouraging things I have learned is that there is very widespread activity in the fields of our interest throughout the country, and in consequence any factual information we may gather is bound to become dated within a very few months.

I have three other preliminary matters to note. First, I have a feeling that the picture of what is going on that I got from Dean Grinter's material is probably closer to reality, probably less slanted in one way or another, than it might be had we in this group done the questioning. The center of Dean Grinter's attention was clearly on what has happened to the teaching of mathematics, basic science and the engineering sciences, so our part of it was relatively incidental, and there was no special pressure to answer in a way that would please us, or annoy us, for that matter. Second, I should explain that Dean Grinter asked for a comparison between what was being done in the academic year 1953–54 and the academic year 1957–58. Any figures I report therefore involve a comparison of what was going on the year before our study started, and what was going on last year, though I have a few comments to make on developments during the

current year. Finally, when I say that we are here dealing with the perfect questionnaire, I will have you know that it was perfect in more ways than one. Dean Grinter appears to have been reporting on replies from 106 institutions, but by the time I got the material, and eliminated duplications, where the same institution sent in two replies, for example, I ended up, believe it or not, with information from exactly one hundred institutions. You won't have to remember your calculus in order to realize the happy consequence that each figure I give you will represent both the raw data and the percentage, all wrapped up in one. Who says research in the humanities and social sciences lacks mathematical precision?

The first basic figure I give you has already been reported by Dean Grinter. It is that out of one hundred institutions replying to the questionnaire, 60 reported changes designed to strengthen the humanistic-social program either quantitatively, or qualitatively, or both. Six institutions reported committees at work that were soon to recommend improvements in the humanistic-social offerings. Thirty-four institutions reported no change, but this figure is deceptive. Upon closer examination I discovered that 14 of these 34 institutions reporting no change, had made no change because they already had, in 1953–54, very strong programs in the humanities. I may add that the figure 14 should probably be larger, because I counted only those institutions which themselves made this explanation or of which I had personal knowledge. I am sure that some of the twenty remaining made no change for the same reason, but I purposely made my count a conservative one.

Basic Findings

Number of institutions replying to questionnaire	100
Number of institutions reporting strengthened humanistic-social progress	60
Number of institutions reporting committees at work on major revisions in H-S programs	6
Number of institutions reporting no change	34
Number of no-change institutions with already strong programs	14

At least it is clear that it would be a mistake to assume that the 34 institutions reporting no change were either indifferent or laggard. On the contrary, the evidence before us would seem to justify the assertion that by now, some 80 per cent of the institutions reporting have either strong or strengthened programs in the humanities and social sciences. I must in fairness add that in a number of instances where I counted an institution as having improved its offerings, the improvement was very slight, perhaps amounting to the addition of only a single semester hour to the total offering. On the whole, however, the improvements were substantial, and I think it is significant that not a single institution reported a decrease in hours or a weakening of its program.

I hope that you will allow me two interpretive comments on the basic picture I have laid before you. First, I have in the past been stung, as I am sure you have, by the charge that engineering schools were giving only lip service to humane and social studies and were in fact diligently avoiding them by various devious devices. One of the reasons I was stung was that I suspected there might be some truth to the charge. I think it is possible for us now to stand up and say that, whatever may have been the case in the past, at present an overwhelming majority of engineering schools are making an earnest attempt to deal adequately with the humanities and social sciences.

If I may be allowed to speculate for a moment, I should say that there has always been a small group of engineering schools that included a strong humanities component in their engineering curricula, that after the Hammond Report in 1944 this group was increased until it accounted for perhaps twenty to thirty per cent of all engineering institutions. But I suspect there were a good many of the remaining schools that held out or made only grudging concessions either because they were not persuaded of the importance of our work, or because they believed the pressure for more and better humanistic-social studies was temporary, it was a fad that would pass away if they

only waited it out. I believe this has now been changed, and that a whole new group of institutions, heretofore generally untouched by the arguments for a strong humanistic-social stem, are beginning to strengthen their offerings in this area.

My second comment has to do with the reasons for this shift. It would be pleasant, though probably self-deceptive, for us to think that our own report of three years ago was a major factor. I will point out in a moment two or three ways in which I think our report may have been influential, but for the overall change in emphasis I know no way of determining how much influence our report had, how much influence the Grinter report, the Hammond report and other earlier reports had. I think we should be realistic enough to recognize that had the engineering profession itself not become persuaded, for whatever reasons, of the need in engineering education for a strong humanistic-social program, we would have been helpless. I have always felt that one of the remarkable things about the educational movement of which we are a part is the fact that it has come essentially from the engineers themselves and is not the result of outside pressures. I think therefore that basically we can claim to have made a contribution only insofar as we have been able, in our reports and in our work, to express and to make concrete the ideas that the engineering profession itself had already become persuaded of.

I must add one further note, however. I think there can be no question that the immediate cause for the flurry of activity in the last few years has been ECPD's revised statement of criteria for accreditation. It is this, I think, rather than the eloquence of our report, that has brought about the changes that my study indicates are taking place. In case some of you have missed it, permit me to quote the crucial statement, under the heading Additional Criteria, as revised for 1958–59:

> Depending upon the definition of humanistic-social studies, [these should be] the equivalent of one-half year to one full year as the minimum content in the area of humanistic-social studies. Of this content, at least one-half year should be selected from such fields as history, economics, government, literature, sociology, philosophy, psychology, or fine arts, and should not include such courses as accounting, industrial management, finance, personnel administration or ROTC.

While this statement may lack something of the clarity and precision that you English teachers are so fond of, I believe it to be in fact an extremely potent instrument for what we certainly regard as the improvement of engineering education. It contains also suggestions which help to explain the developments with which I shall deal in the remainder of this report.

Surely one of the most pressing problems confronting engineering curriculum builders is the problem of finding time for a sound humanities sequence. From the evidence I have examined I should say that the major new development in meeting this problem has been the growing practice of eliminating or cutting down the academic credit allowed for ROTC courses, with the resulting gain going preponderantly to the humanistic-social work. At least eight schools reported moves in this direction, and several others have them under study. As one sympathetic to the needs of the armed services, I find myself somewhat concerned as to what this may do to officer procurement, but I cannot fail to report the fact that this seems to be an increasingly popular solution to the problem of time. You will remember that in our report on *General Education in Engineering* we called special attention to the fact that the ROTC programs were eating heavily into the humanities work, and you will also recall that ROTC work is specifically excluded from the content of the humanities program in the ECPD statement.

Time is also being found by the elimination or consolidation of courses in Surveying, Machine Shop, Welding, Drawing and even, though here it is of course consolidation, not elimination, in Physics and Chemistry laboratory work. Another group of courses being eliminated or made elective, perhaps as a

result of the recommendations in our report, includes Business Law, Accounting, Engineering Economics, Business Administration, and—some of you will not like this—Speech and Report Writing.

Two institutions report that they have found it necessary to increase the number of hours required for graduation, and one of these has added a required summer session for all who expect to complete the program in four years.

Beyond the mere question of time, I think it is clear from the evidence I have studied that the contention of our report that a humanistic-social program ought to be truly humane and truly social has been taken seriously. Both the replies to the questionnaire and the ECPD statement would seem to indicate that there has been a considerable sharpening of the definition of what the humanities and social sciences are.

I come now to the most controversial of my findings, and while it is controversial it certainly demonstrates the wisdom of the planners of this program, because it has to do with the question our next speakers will discuss, namely whether a rigid, required sequence is preferable to a maximum of free election. Out of eleven institutions commenting on this problem, the split would, I think, have been exactly even had it been possible to divide eleven into two even numbers. I think it is fair to say also that both sides appear to feel very strongly about the matter. Let me give you two quotations from each side to indicate the tenor of these comments. One institution reports:

> The socio-humanistic program has been changed in such a way as to keep the requirement of specific subjects to a minimum. Instead a program is required involving at least 6 hours in the humanities, at least 6 hours in the social sciences, and at least 12 hours in one specific subject included in these major fields. This has been done because the wide diversity of preparation in the socio-humanistic subjects makes set patterns at this institution somewhat ridiculous.

Another institution reports as its major improvement in this field "the availability of a wide range of courses in the social sciences and humanities fields offered by our liberal arts college instead of a special sequence open only to engineering students as was the practice heretofore."

On the other hand, listen to this:

> The matter of elective studies is not at all satisfactory in the undergraduate program and we find there are too many students interested in the hours rather than educational content. Perhaps it would be well to specify areas in which this elective must be selected.

Or hear this:

> We hope that current arrangements will give coordination and unity to our humanities effort, which was previously completely elective with the result that students tended to elect the courses most easily scheduled or which they thought would be easiest.

Finally, let me quote from another reply that appears to fall somewhere between the two extremes:

> In addition to two courses in English, all engineers take seven elective courses in the humanistic-social science group. There are some restrictions on this. We do not wish engineers to elect seven different freshman or sophomore level courses. In order to gain some depth, we restrict juniors and seniors to electing junior and senior courses in the Liberal Arts School, thus they can build only on areas in which they have prerequisites. Personally, I am not as impressed by a large number of elementary non-technical courses as I am by penetration in one or two areas.

I think it is clear that this problem of a planned and integrated sequence versus freedom of choice is still an extremely vexing one in many institutions. I hope I will not destroy the sharpness of the debate between the next two speakers if I conclude my report with a general observation drawn from my study of the replies to these questionnaires. I think I see emerging as a reasonably common pattern a compromise between the claims of the tightly integrated sequence and the maximum of free election. More and more, it appears to me, programs are beginning with one or two basic required courses taken by all engineering freshmen and sophomores. Beyond this, wide latitude in election is allowed, with only the kinds of restriction that will assure

some depth in at least one area, that area, however, to be freely chosen by the student.

In summary, then, I should say that the picture I get from examining Dean Grinter's material is as follows. During the last few years there has been an obviously widespread attempt to do justice to the humanistic-social component in engineering education, and this effort has involved a great many institutions that had not previously done much in this direction. Time, as always, remains a major problem, but the time is being found by one means or another. There appears to be emerging a definition of the content of a humanistic-social program that does justice to the humanities and social sciences as major areas of human knowledge. There appears to be continued groping and experimenting with the question of how best to structure such a program, and I should say that the biggest unresolved problem as of the present moment involves the conflicting claims of those who favor a required, integrated sequence and those who favor a maximum of free election. I think it particularly important that this problem be further studied and discussed, as I believe it will be by the speakers who follow me this morning.

U. S. FUNDS FOR BASIC RESEARCH ESTIMATED AT $1 BILLION A YEAR

The National Science Foundation has estimated that total funds for the performance of basic research in the United States reached a level of $1 billion in the year 1959–60.

The bllion-dollar estimate is based on an NSF statistical series published today, "Funds for the Performance of Basic Research in the United States, 1953–58," *Reviews of Data on Research & Development*, No. 22.

The statistical series, compiled through extensive NSF surveys of the 1953–58 national research and development effort, indicates that basic research funds rose from about $430 million in 1953–54 to more than $830 million in 1957–58, an increase of 93 per cent. Throughout this period, funds for basic research continued at a level of about eight per cent of the total estimated R&D funds. Total R&D funds in the United States reached a $12 billion annual level for 1959–60, according to the Foundation.

The substantial rise in the level of basic research funds is part of a "long-term increase in scientific and technological activity stimulated, in particular, by the challenging problems of the past two decades," the Foundation said.

The series indicates that colleges and universities expended about half the national total in the performance of basic research in the 1957–58 survey year. The industry sector reported using about a third of total funds for the same purpose. Performance of basic research by both the Federal Government and other non-profit institutions accounted for a relatively smaller portion of funds, 13 and 6% respectively.

A New Plan for a New College

W. H. DAVENPORT

Chairman of Humanities
Harvey Mudd College
Claremont, California

Harvey Mudd College opened its doors for classes in 1957, has 110 students and will eventually run about 300, and its ideas about humanities and social studies for engineers and scientists are largely on paper. When Mr. Olmsted asked me to take part today, I demurred for obvious reasons, but was told that new sets of figures and new combinations of familiar ideas, especially when imported 2500 miles from California, would interest an audience. The title of my report is Mr. Olmsted's work, for he had to meet a printing deadline before I could come up with something apt. As we go on, I think you will agree with me that in front of "New Plan" we ought more realistically to insert "Prolegomena to–."

I have distributed copies of a booklet describing the work of our faculty summer study a year ago; this will be useful as propaganda and reference, and may well save time if I can occasionally say "See page so-and-so." [1] If you will study pp. 48–9 you will see that the College is aware of the aims of ASEE committee reports of 1940 and 1944; likewise you will note that the founding fathers stressed, not mere factual knowledge, but mastery of principles on which change is based, exercise of imagination, and broad-base training producing not specialists but men able to adjust to and work out specific situations of varied types. And, from the beginning, to quote the *Bulletin*, "The College was founded in the belief that a special need exists for physical scientists and engineers sufficiently broadly trained in the social studies and the humanities to assume technical responsibilities with an understanding of the relation of technology to the rest of our society."

[1] Available from the author on request.

I have been told that we are the first private school of engineering and science to be founded in this country in thirty years. (I have never been able to find out what the last one was!) Why do it? Well, besides the usual idealistic reasons there are some compelling local reasons. With 80% of the higher education outlets in the State of California under the control of the State universities, colleges, and junior colleges, most of them offering engineering, and most of them huge, there seemed to be a place for a small, private, quality operation. We were aware of the importance of the humanities and social sciences–of their utilitarian value, their help in developing the whole man, their necessary place in aiding the man of technology (now moving into the position of national leadership once held by financiers and lawyers) to know not just what he can do, but should do.

You in the audience have the advantage of experience. You are blooded by virtue of having fought your way, holding the line for curriculum percentages and battling trustees or regents for every unit of non-technical credit. We have the advantage of starting fresh and starting whole, but we are if not as ragged, surely as raw as Falstaff's army. With the aid of organizations like the Fund for the Advancement of Education and the Carnegie Corporation and others we have initiated a program calling for small output of high quality; we will never produce more than half of one percent of the nation's engineers. We are blessed with a student-faculty ratio of eight to one. Our classes average fourteen, with no single section over twenty. (Mr. Ruml would say this is a bit foolish.) Our trustee-faculty-student relationship

has been almost unique from the start, with interlocking committees meeting around the table with utmost informality. Next fall's freshmen (65 of them) as a class average over 600 on the verbal test; they average 700 in math. We have just graduated our first class (two senior transfers), and have been accredited by the Western College Association.

Harvey Mudd, as you can see, has advantages at the start, but it has its own brand of problems, not just of survival financially, for example, but of theory and practice for a special type of student. We are *requiring* every student to take one-third of his work in the humanities and social sciences. To require is one thing. What to require or suggest is another. I may say in passing that all students take the same program across the board during the first two years: basic courses in math, physics, chemistry, engineering problems, English, and history. Work in the major during the last two years leads to a B. S. in engineering science: we do not have M.E.'s, C.E.'s, et cetera. Our concern today, of course, is what to do about the humanities-social science program, especially in the last two years. We have studied your programs, visited your schools, conned the reports, staged conferences. We believe that the humanities and social sciences should be one department, and further that they should blend into and out from science courses, our opportunity for coordination being unusual. From the start we have picked technical faculty well disposed to and trained in humanistic-social areas. We believe in a substantial number of required subjects in the h-s program, but feel that considerable election should simultaneously be allowed. The percentage of *h* to *s* is roughly 50–50. We hope to recast familiar material and also come up with local variants or inventions in the spirit of "venturesomeness." With a small faculty we will have limited offerings in the upper division of h-s; here, however, the local situation, virtually unique, comes to our aid. The Associated Colleges at Claremont include (in addition to HMC, the baby) Pomona College (co-ed), Claremont Men's College, Scripps College (girls), and the Graduate School—all independent and yet mutually assisting bodies. We can share faculty and students on occasion. If a junior at HMC wishes a course in Abyssinian Art at Scripps, he can take it for credit in his home unit. So our elective possibilities are comparable to those of a large university.

We feel, further, that no course in h-s should be taught with engineers and scientists in mind. There should be no "Engineering English," for example. We want writing for four years and in all courses, technical and non-technical. We talk of a senior project combining work in technology and h-s. In the main we hope to produce generalists with individuality, however paradoxical this may sound, and send our products to graduate school (where most of them are headed) or to industry, where re-training is almost inevitable anyhow.

Since classes had to be met, we set up a conservative, standard program for the first two years: freshman English, sophomore survey of literature, sophomore history of Western civilization. Next year's juniors may elect humanities courses and/or social science courses at HMC or the associated colleges on the smorgasbord principle for this year and probably next. By the fall of 1960, however, we must have a four-year program set up in h-s which will have some real organization, depth, breadth, coherence, and relation to the local scene. In last summer's Carnegie-financed study we assembled experts from across the land to sit with our faculty and, hopefully, come up with THE plan for Harvey Mudd. You can see what happened: we wound up with FOUR plans.

The booklet contains many details, but for the moment I must compress for quick comparison. The Chapman plan calls for 6 units of introduction to h-s the first year and three more the second year along with three units each of economics, literature, and government. The junior year offers three units in each of four courses: art and music, group behavior, elective in area of concentration, and free elective. The final year suggests three units each in elective area of con-

centration and senior project and six units in study of the individual in modern culture. This plan is not concerned with vertical or horizontal stress, nor is it scatter-shot or post-hole merely. Relatively, however, it is loosely-knit. It can, like the rest, work out satisfactorily.

Mr. Jenkins is a philosopher. It is not surprising, therefore, if his plan is idea-centered. Note six hours of appreciation, analysis, and communication plus four hours of intellectual and institutional history the first year; three hours each of contemporary American culture, psychology, and art/literature the second; three hours of ontology/epistemology, theory of law and state, comparative contemporary cultures or economics the third year; and three hours of value theory plus nine hours of electives for most students in the final year. I think you will agree that this program is solid enough.

Mr. Phelps combines the spray approach (nine courses in six subjects) with the concentration approach (six/seven courses in one of the following fields): economics, literature, political science, history; the latter feature is the equivalent of a strong minor, if not a second major. This too is a challenging possibility, particularly with our local organization.

Mr. Rieff, a behavioral scientist, suggests an all-faculty basic course freshman year in science and religion; six units of social systems taught by the *soc* part of the hum-soc faculty and six units of culture in transition taught by the *hum* part in the sophomore year; six units of modern personality and culture given by combined soc-hum faculty in the junior year; and six units of social science concentration plus six of humanities concentration during the senior year. This program suggests problems of hiring and training, but on paper offers food for discussion. You have probably noted one point common to most of the foregoing notions: how difficult it is for an expert in one field not to center the whole program around his field.

These plans are not finalized, to use a horrible term popular at recent conventions; we have yet to maximize the payoff function, to use another. The plans are not the only possibilities either. A quick emergency solution, a seat-ejection approach, could consist of introduction to humanities in the freshman year, the retaining of literature and history in the second, a required three-semester block of humanities in the last two years with concentration on the Greeks, the Renaissance, and the moderns; plus four semesters of free electives in the social sciences (either four one-semester courses or four semesters of one subject). However, with our favorable start and benign auspices we would like to make an h-s program of outstanding significance, combining the best of the tried with some fresh approaches. We now face the issue: how to pick from or combine the foregoing ideas? This summer our faculty will sit down to make a decision. What would *you* do with our type of student and all those units to play with? Perhaps in the discussion to follow, certain listeners, intrigued by a detail here or there, will care to suggest a master plan for our local scene. As I said at the start, the "new plan" is not ready—merely some yeasty ideas for one. Since we all, large universities and small colleges alike, old and new, wish to serve the country as best we can in science and technology, we have everything to gain mutually from reports on recent activity. It is possible that some of our unresolved ideas may be of use on your local programs. It is with this sentiment in mind that I have brought you news of our experiment in Claremont. If some of you expected me to furnish new answers to old questions, I am sorry. Perhaps five years from now. Meanwhile, others of you may have caught today a little of the excitement of founding a new college and may sympathize with some of the inevitable confusion. We shall be grateful for advice from you who have made and re-made many programs.

The Core Curriculum of the School of Humanities and Social Sciences of Rensselaer Polytechnic Institute

WILLIAM PEASE

Associate Professor of History, Rensselaer Polytechnic Institute

In 1953 Rensselaer Polytechnic Institute began a major overhauling of its academic structure both to increase the efficiency and effectiveness of its teaching and to bring the Institute more nearly into line with educational practices elsewhere in the country. At this time the various major areas of study—science, engineering, architecture, and humanities and social sciences—were designated "Groups." Then, in 1957, these Groups became "Schools," gaining in the change a stature similar to that of the College within a University.

As this growth proceeded, the development of the humanities and social sciences proceeded with it, till in 1958 Rensselaer began to offer, for the first time in its nearly one hundred fifty years, a B.S. degree in the humanities and social sciences (specifically in the fields of English, Philosophy, Psychology, and Economics). But not only did a major program in the School of Humanities and Social Sciences develop. A program of general education, called the Humanities Core Curriculum, was growing as well. This Core Curriculum began to operate in the fall of 1957 with the then freshman class; and, including a new class each year, it encompasses, in 1960–61, all undergraduate students at R.P.I. During the past several years, therefore, the constructing of the Core Curriculum has been a major concern of the faculty of the School of Humanities and Social Sciences.

There are at least two basic issues which confront the liberal arts curriculum planner in an engineering school. First, the number and variety of courses to be included in the curriculum; second, the internal structure of the courses in that curriculum. The number and variety of courses may be determined by an all-or-nothing principle which proliferates courses without stint. This is an attempt at cultural saturation dependent on quantity alone. If, however, a merely quantitative curriculum be judged formless and pointless—an all-therefore-nothing criticism—another principle may be evoked, the principle of planned limitation. Two curricula may emerge from planned limitation; one, whose limits are determined by the desires of the engineering, science, or other professional departments and whose nature is, therefore, solely that of a service curriculum. The second alternative of planned limitation returns planning to the liberal arts faculty, thus permitting an optimum limited curriculum which will require at least a minimum diversity within the liberal arts, a minimum guarantee of basic courses, and a maximum utilization of staff capacities.

Several choices of principles are also available in determining the internal structure of courses within the curriculum. The first is the abdication principle—otherwise known as the let-the-chips-fall-where-they-may theory. A second alternative is the principle of discipline structure, which demands that all courses in the curriculum correspond, in content and approach, to traditional academic disciplines. A third principle is that of coordination, which assumes distinct subject areas but encourages classroom demonstrations and utilizations of interrelationships and common ground among the various disciplines. Finally, there is the principle of integration, consequent upon which departmental barriers are lowered

(or disappear), subject areas merge with one another and, as a logical conclusion, all courses become but a single course, variously called "interdepartmental" or, better still, "civilization." The Humanities Core Curriculum may be described, in the terms already used, as optimum and coordinated.

The basic premise of the School's educational philosophy is that people are people. There is, in other words, no special brand of liberal education for scientists and engineers as opposed to liberal education for non-scientists and non-engineers. What is taught in the liberal arts curriculum either is liberal arts or is a bastard product called liberal arts for the engineer or for the scientist or for the architect. It reminds one of nothing so much—to do violence to Dylan Thomas—as those easy "Instructions for Little Engineers." Rensselaer aspires to teach liberal arts.

A second educational premise is flexibility. Any academic program should be flexible enough to permit constant experimentation and to incorporate a variety of useful and productive approaches. This is not tantamount to formlessness, nor does it preclude a predominant structure. The concept of Coordination allows for the integrity of individual disciplines, yet permits some degree of integration. The Humanities curriculum tries, through Coordination, to avoid the deceptive all-inclusiveness of total integration. The trouble with fragmentation is that it may become mere narrowness, both of teacher and of student; and that it may produce a formless education. But integration may produce equal formlessness, for integration demands that there be something to integrate, and this demands thorough and extensive knowledge, both of the teacher and of the student. As a mature and experienced person, the teacher may perhaps approximate Renaissance Man. But what of the student? Too often, in short, the fully integrated program will be excellent education for the instructor, poor education for the student.

A third educational premise, perhaps self-evident, is that any curriculum as a whole and each course in that curriculum should be of the highest possible calibre. If it is undesirable to build course and curriculum for a specific variety of student, it is equally undesirable—indeed probably more undesirable—to teach what is taught on an elementary level. Rigorous, demanding, exacting teaching may exhaust or discourage the faint-hearted student; teaching down to him, however, insults his intellect.

The liberal arts plan of the School of Humanities and Social Sciences envisages a varied and coordinated curriculum taught with vigor and challenge. An ideal education would leave no area of intellectual, spiritual, and artistic endeavor unexplored. But in the real world every school must limit that exploration at least by the number of hours provided it in the total college curriculum. The liberal arts at Rensselaer make up twenty-four credit hours in four years—three credit hours for each semester in the undergraduate curriculum. This is about sixteen per cent of the total number of credit hours necessary for graduation. What Humanities is doing with these credit hours and, more importantly, why it is doing it is the burden of this essay.

The Core Curriculum is divided into the prescriptive freshman and sophomore years on the one hand, the elective junior and senior years on the other; as the table shows, the latter is then divided into a first semester junior elective called "limited," a second semester junior elective called "free," and one two-semester course in the senior year. Specifically, the question implicit in this structure is this: "Within the time limits externally imposed on a liberal arts curriculum, what areas of the liberal arts, above all others, should every student be exposed to? Acquaintance with what areas—if indeed it is possible to make such a distinction—is indispensable for the educated, responsible, humane adult?" The School of Humanities and Social Sciences has answered that question by including in the first two years of the liberal arts curriculum three areas: English, History, and Economics.

THE CORE CURRICULUM

THE SCHOOL OF HUMANITIES AND SOCIAL SCIENCES
RENSSELAER POLYTECHNIC INSTITUTE

	Fall Semester	Spring Semester	
Freshman	(1) Area: English I (Uses of Language)	(2) Area: English II (Introduction to Literature)	Basic Core Curriculum. Required of all students without exception. No electives possible.
Sophomore	(3) Area: History (Modern Europe since 1789)[1]	(4) Area: Introductory Economics (Introduction to Economic Theory and Method)[1]	
Junior	(5) Limited Elective Areas:[2] Anthropology, Fine Arts, Philosophy, Psychology, Music, Political Science, Sociology, Foreign Languages[3]	(6) Free (Unlimited) Elective (In general, all Junior-level courses)	Limited and unlimited electives. Required of all students.
Senior	(7) One-Year Senior Elective	(8)	R.O.T.C. omits the senior year.

[1] History and Economics divide the sophomore class, so each area is actually taught both fall and spring.

[2] These are the areas of election originally approved. They are subject always to revision and alternation. In general only one course per area is permitted.

[3] Third term courses in foreign language, or first term courses in foreign language, if that language is the second foreign language studied at R.P.I.

English, History, Economics! What a pitifully small and inadequate core. To improve the situation, therefore, the initial question was extended. "Given further choice, what additional areas would be a desirable part of the basic education of the mature individual?" In the answer to that question is the rationale of the "limited" elective in the first semester of the junior year. In this semester every student is introduced to one further academic area which he has not yet studied from among areas all of which ideally he would study.

For his first two and a half years, therefore, the choice of the student has been severely restricted—where indeed he has had any choice at all. Yet it is desirable that students be able to investigate areas of particular personal interest. On this premise the rest of the Core Curriculum rests. The most critical moment in the student's undergraduate liberal arts education comes precisely, therefore, between the first and second semesters of his junior year. At this point he becomes a free agent, free to determine his remaining liberal arts curriculum. There are two distinct alternatives now open to him: breadth or depth, generalization or specialization, dispersion or concentration. He may choose to investigate another area in his "free" junior elective and to study in still another area in his senior year. Or, if he is so minded, he may concentrate his ef-

forts so that he may accumulate, in a given subject matter, twelve to fifteen credits over a four-year period.

The senior elective, in fact, is the course in the entire Core Curriculum which is potentially the most significant. It has been called the "Capstone" course, suggesting that it finally seals off the liberal arts training of the student. The term is, however, not very meaningful. Better call it the Keystone, for it is the course upon the strength of which the Core Curriculum stands or falls. For the student it is the senior elective which gives him either the final breadth or the greater depth in his liberal arts education, and which, in either capacity, gives concrete and lasting significance to his four years of study in the School of Humanities and Social Sciences. And for the faculty, too, the senior elective is critical. Here one can experiment most widely with discipline in depth, with inter-departmental coordination, and with inter-disciplinary integration. Carefully selected, imaginatively conceived, and rigorously taught, the senior elective will not be merely the final course in a series of courses, but it will be also the thoughtful conclusion of an orderly, related four-year sequence.

It is particularly against the junior and senior years of the Humanities Core Curriculum that the loudest objections will be heard. To some the plan suggests an unhealthy specialization; to others a vacuous superficiality. Each group will perhaps grudgingly admit the theoretical value of the other's position. But the integrationists then will challenge this kind of specialization as not being specialized enough. And the specialist will, in the same way, point out that such a limited breadth is certainly not broad enough. Such contention, however, is pointless, for each knows his own solution is best; yet the fact remains that if one may know more and more about less and less, till he at last knows all about nothing, he may equally learn less and less about more and more, till he at last knows nothing about everything.

The second major premise, set forth earlier, was that a curriculum should be flexible enough to guarantee both diversity of approach and thoughtful experimentation. It may indeed appear that the Core Curriculum is taught and administered by independent departments representing distinct disciplines. That suggestion is indeed true as practice, though administrative division is not wholly complete. If one can discover but two official departments—Language and Literature; and History, Economics, and Political Science—one can discover that as a practical matter there are a variety of autonomous areas: Literature, History, Political Science, Foreign Language, Music, Economics, Philosophy, Sociology, Fine Arts, Anthropology, and Psychology. Within these areas it is thus possible both to develop courses in special fields and to bring each discipline's special insights and techniques to the broader integrated courses.

The relevance of the Core Curriculum for the student is, of course, readily evident. Beginning with a fairly traditional framework in the first two years, the Humanities Core Curriculum progresses, in the later years, to an ever-increasing freedom for experimentation in which the possibilities are, theoretically, almost unlimited. And this progression from the traditional to the experimental as well as from the basic to the complex is in the precise order in which the student himself becomes ever more mature and able to cope, with profit, with such diversity of approach. The structure of the Curriculum is, in short, of the greatest importance to the student body.

The Humanities Core Curriculum is a coordinated sequence of courses beginning with basic and essential disciplines and advancing by logical and interrelated steps through advanced courses either in specialty or in breadth. It is designed to provide a wealth of diversity, a richness of experimentation, and an optimum of rigor. It is predicated upon the belief that the liberal arts are the common necessary equipment of all mature, responsible, and educated people. That the Core Curriculum has its weaknesses and limitations goes without saying, not because it is still new and but little tried, but because it is a human product. It

begins with a point of view and has, therefore, both purpose and form. To expect all to agree with it is as undesirable as it is futile.

There are those, the faint-hearted, who will object that the Core Curriculum is too big a program, that it tries to do everything at once. There are those, the innovators, who will be quick to point out that there is too much in the curriculum which is traditional. There are others, the specialist-scholars, who will fret because their own special areas somehow find no home in the Curriculum and who, more importantly, resent the apparent necessity to coordinate and the implied pressure to integrate. There are those, the integrationists, for whom discipline courses and departmentalization are mere synonyms for formless and pointless fragmentation. And there are those, the hard-headed pragmatists, who will fail to understand a curriculum devoid of professional utility, practicality, or just "usefulness."

They are all quite right—each from his own vantage point. And for each there is a reply. It is too big so that it may be richly eclectic; it is traditional insofar as that which is traditional is, in Burke's sense, the best of the past; it is non-specialist precisely because it is general, not professional, education; it is departmentalized and disciplined to insure, insofar as possible, that very breadth which is meaningful only with depth; and it seems impractical and useless just because it aims at the whole man, not at the professional man.

There is probably no objective measure by which one can determine that the Rensselaer Humanities Core Curriculum, or any other liberal arts curriculum, is inherently and by performance unquestionably superior to all others. Student opinion is at best dubious. Alumni recollection is that of the fondly reminiscing "old grad." And to judge merit by the considered statements of involved faculty is to elicit only sophisticated testaments of faith. It would be as silly to say with Dr. Pangloss that this is the best of all possible worlds as it would be satisfying to say with Lincoln Steffens that we of the School of Humanities and Social Sciences have seen the future and it works. Pangloss was a fool and Steffens was mistaken. All we can say is that the program has a plan and that to us it seems to derive logically from its premises. We hope that it *will* work. We think that it *is* working.

$71 MILLION R&D FOR ENGINEERING SCHOOLS IN FISCAL 1958

Engineering schools in the United States reported that they spent $71 million for "earmarked," or sponsored, research and development in fiscal year 1958, according to information released today by the National Science Foundation.

Engineering schools received $48.6 million of this total from the Federal Government and $10.3 million from industrial sources. Direct support of R&D from their own funds was $10.5 million, plus an additional $3.5 million to cover the indirect costs of outside-sponsored grants and contracts.

The 129 engineering schools, either independent institutions or affiliated with colleges and universities, were part of a comprehensive survey of expenditures and manpower for research and development in colleges and universities.

Twenty schools reported expenditures of $1 million or above for research and development, 85 reported between $25,000 and $1 million, and 24 reported expenditures of less than $25,000.

Of the $71 million total, 57% was reported as going for basic research, in contrast to the 45% reported in a comparable previous study covering fiscal year 1954.

These and other preliminary data from the Foundation survey were issued in *Reviews of Data on Research & Development*, No. 21, "Funds for Research and Development in Engineering Schools, Fiscal Year 1958."

The Community Survey Course as Integration

WILLIAM W. WAITE

Professor and Head of
Industrial Engineering, Columbia University

Before going into the purposes and operation of this program in detail, I think it would be well to give you a resumé of the background of the students and the curriculum which they have followed before they enroll for this course. The Columbia Engineering School is a professional school and admission is granted only after the student has completed three years of liberal arts work* either at Columbia College, Barnard College, or the School of General Studies at Columbia; or at one of the forty-odd liberal arts colleges scattered throughout the country with which we have contractual arrangements. Under this program, the student takes three years at his liberal arts college followed by two years in the Engineering School. After completing all the work satisfactorily, he receives two degrees, an A.B. from the liberal arts school and a B.S. from Columbia Engineering.

The course I will describe to you this afternoon is given during the summer vacation immediately preceding the student's entrance into the first year of engineering. It is designed not only as an integrative experience, but also as a transition between the strictly liberal arts work and the strictly scientific work. Its integrative effect is obtained by tying together the humanistic-social concepts which the student has presumably developed during his first three years and the scientific concepts which he will undertake to develop later. We attempt to show him that there is a meaning and an application in real life to the material he has been studying and that these subjects, plus the rather varied technical program to which he will later be exposed, are all integrated to the accomplishment of a specific purpose.

Our students come from widely diverse backgrounds. A large proportion of them are, of course, residents of large cities, with the New York metropolitan area predominating. Others, particularly those coming to us from the combined-plan colleges, have had considerably less exposure to metropolitan life. We have found, however, that all have one characteristic in common. They are uniformly inexperienced and generally uninformed concerning the detailed operation of a modern community. Like most other citizens they tend to take for granted the community services and the interrelationships among the different factors of life in their home towns and cities. This deficiency we seek to remedy in the Community Survey Course at Camp Columbia.

The course has a number of purposes, principal among which is the provision of an educational experience which it is impossible to give the men in any other way during their careers at Columbia. It is simply not feasible to attempt to describe verbally or pictorially the kind of thing we can show them in the field. The University owns approximately a square mile of fields and woodland in northwestern Connecticut on which a surveying camp has been maintained for Civil and Mining Engineers ever since 1891. Just after World War II, it was decided that students from other departments could benefit from the camp experience and, therefore, all incoming juniors were required to attend. The course originally devised for the Elec-

* We do have an arrangement with Columbia College, the men's undergraduate liberal arts branch of the University, by which a student taking a special two year course can be admitted. However, the number of such people is becoming fewer each year.

trical, Mechanical and Industrial Engineers consisted of a series of plant visits covering a three-week period during which one or two plants were visited daily. At the end of the course, however, it was found that the students had considerable difficulty in remembering what they had seen there. Their impressions were befogged by constant repetition, and it was soon decided to modify the course.

As a substitute we tried out the Community Survey, in which a medium-sized industrial town within easy traveling distance from camp was selected and given a fairly complete study. We divided the coverage into three general areas: industry, public utility services, and the community itself. Each student team is assigned generally to one or, at most, two industrial operations, a public utility, and a specific aspect of the town government or civic life. They become, if not experts, at least specialists on these particular activities and are required to report at periodic discussion sessions to their fellow students so that the information is made generally available to all. Each student team prepares a written report in addition to the oral report, and from these written statements the staff members of the course prepare a descriptive booklet on the town. This is published during the regular academic session immediately following the summer survey and is distributed not only to the students who participated in the survey but also to those members of the community who aided in any way in compiling the information.

We have emphasized consistently in these booklets that the information in them has necessarily been obtained by the students from some individual or group in the community and that we cannot, therefore, claim any great amount of originality. However, it is usually the first time that the information has been collected together in one place, and civic leaders, newspapermen and other persons in the community have found it a valuable asset.

In addition to this specialized educational experience, we expect the students to gain some understanding of the interrelationships which exist among the various factors of life within the community and to realize that any change in one of these factors must necessarily have an effect on the others, usually an immediate one. This is something else which most of the students have not recognized before, and we make an effort to tie it in with the realization that the engineer, as one of the better-educated and better-qualified citizens of the community, has certain civic responsibility for the sociological effects of his technological action. This follows along the same line as Professor Hall's statement of the engineer's civic responsibility in a modern society. We have perhaps been fortunate in that the communities that we have studied have produced a number of engineers who, in addition to their work in local factories or utilities, have also been working on community activities such as Parent-Teachers Associations, Boards of Finance, Boards of Education, and so on. We have been able to point to these men as examples of how we hope our own students will eventually develop.

Some of the students have found the course a help in career selection. They visit and hear about a variety of activities and often are able to decided that certain careers are definitely not interesting and that others are worth further investigation. They can see how other graduate engineers work and progress, and they form their opinions accordingly.

I have already mentioned the purposes of transition and integration, but there is another aspect which we feel is valuable. The men are required to visit the executives of industrial, commercial, and utility organizations and to obtain from them certain specified information. In most cases we have "opened the door" to organized community activities. However, even in these cases, the students must still present their questions in such a way that the respondent will give them the information they need. In addition to these formal visits, we require each team to make approximately fifteen unscheduled calls on citizens whose names have been selected at random from the town's voting list. On each of these visits, the student must secure certain in-

formation regarding the respondent's economic status, political philosophy, general knowledge of the town, and opinions concerning various aspects of government. Experience in the past has shown that the students can obtain this information with a minimum of difficulty and that the vast majority of citizens are quite cordial and communicative. There have been a few cases in which people have refused to answer any of the questions and others in which the identity of the student has been questioned. We have been able to handle the latter difficulty rather easily by supplying the men with letters signed by the Dean of the school, identifying them as bona fide students at Columbia, and with letters from the Mayor or Chief of Police of the town being studied, stating that the survey has been cleared with local government officials and is approved. We also secure advance publicity in local newspapers so that, hopefully, most of the people in town will at least be aware that the survey is under way. However, it appears that some people do not read their local newspapers. The experience of making a contact with the purpose of securing information is one which the students will have to repeat many times in later life and we feel that the sooner they gain some experience, the better.

So much for the purpose of the study. Let us now look for a moment at the details of operation. As I have already mentioned, each student is expected to become a specialist on some phase of industry or utility work or municipal government or civic activity. In some of the larger factories we break down the plant into segments and require members of the student body to report specifically and in some detail on such operations as production control, personnel administration and labor relations, engineering and design, quality control, or marketing. However, most of the plants we visit are small enough that the student can cover the entire operation and obtain a satisfactory idea of its details.

The men attend town meetings which, incidentally, seem to fascinate most of the "city slickers" whose experience has taught them that an attempt to present an individual citizen's views to the Mayor and Council of New York City is an undertaking beyond the capacity of the average citizen. We get in touch with religious leaders, the Visiting Nurse Association, veteran's organizations, service clubs, the heads of civic organizations such as the Red Cross, and citizen's watch dog groups wherever they exist. We visit the local hospital, doctors, dentists, and others concerned with community health. We spend time with the fire, police, and other protective service organizations, and we study the water supply and sewage disposal. Telephone, electric light, gas, railroad, and bus companies have been uniformly cooperative and helpful in explaining the place which each of their organizations fills in the life of the community and the material contributions which it makes in the form of taxes and wages. When all of the information has been collected, it generally presents a rather imposing appearance, particularly to one who must read, grade, and edit it. However, we feel that the results justify the effort.

And, speaking of results, we feel that we have two groups to be served: the students and the community. When we make our first contacts in town with the local government officials, we stress the fact that this must be considered as primarily an educational experience for the students, that any benefits to the community must be incidental. We are coming to town with a young, untrained, inexperienced group to work for a relatively short time on a problem for which past training and experience have by no means adequately qualified them as investigators. We therefore point out that we will not publish in our booklet any conclusions or suggested solutions to local problems. Parenthetically, I might say that the students are strongly encouraged to arrive at conclusions and to suggest ways and means of alleviating problems, but to confine these suggestions to their reports and to the discussions held at camp. We try to avoid taking definite positions on the controversial issues which we find in practically every community that we study. Our

published reports naturally mention these issues, but we try to be scrupulously fair in stating the positions of both sides, leaving the readers of the reports to draw their own conclusions. As a result of the course, the students have developed a much greater awareness of what it takes to make a happy, successful, growing community. They also have become aware of the place which their studies are likely to fit them to occupy in later life. For the community, the survey has generally resulted in a greater awareness of itself and its problems and also of Columbia University. We feel that the latter effect is by no means the least desirable which we have accomplished.

In summary, the Community Survey Course has been an effective means of integrating in the minds of our students the liberal arts courses which they have taken prior to entering the engineering school and the more specialized technical work which they will take up later in their careers. It serves as a transition between non-technical and technical work. It has developed a greater awareness on the part of the students of some of the essential facts of the life which each one of them will have to lead after he graduates and it has, we hope, served to develop at least some of our students as better citizens than they might otherwise have been.

Teaching Positions Available

OPPORTUNITIES AT OHIO COLlege of Applied Science, Cincinnati, Ohio, for qualified men in Electrical Engineering Technology and Civil Engineering Technology. Preference given to a Professioal Engineer who would like to teach application. These jobs are challenging with excellent future possibilities. Address inquiries to Dean Edward L. Fleckenstein, Ohio College of Applied Science, 1104 Walnut Street, Cincinnati 10, Ohio.

MECHANICAL ENGINEERING teaching position. Assistant and/or Associate Professor needed. Consulting, research, and development work permissible and available for extra compensation. Giving full information, apply to: Professor C. O. G. Wittig, Head of Mechanical Engineering Department, Speed Scientific School, University of Louisville, Louisville 8, Kentucky.

TWO OPENINGS IN MECHANICAL engineering for young Ph.D.'s—one in thermodynamics-heat transfer and one in design. Research opportunities. Walter J. Seeley, Dean, College of Engineering, Duke University, Durham, North Carolina.

MECHANICAL ENGINEERING—ASsistant or Associate Professor to teach Thermodynamics, Heat Transfer and Gas Dynamics. M.S. degree required, Ph.D. desirable. Rank and salary commensurate with qualifications. Position available January 30, 1961. Write E. R. Stensaas, Head, Department of Mechanical Engineering, South Dakota School of Mines and Technology, Rapid City, South Dakota.

ASSISTANT OR ASSOCIATE PROFESsor of Mechanical Engineering interested in machine design and metallurgy, to teach in undergraduate and expanding graduate program. Sponsored research encouraged. Salary commensurate with qualifications. Apply to W. M. Petry, Head Mechanical Engineering Dept., University of Akron, Akron 4, Ohio.

CIVIL ENGINEERING ASST. PROfessor or Instructor needed. M.S. Degree desirable but Instructors working toward advanced degree or one experienced in the Highway field will be considered. Start February 1, 1961 or before. Write Earl D. Dake, South Dakota School of Mines and Technology, Rapid City, South Dakota.

KINEMATICS SPECIALIST WITH analytical and design interests, for research and teaching, including mechanisms and advanced kinematics, assistant or associate professorship, start February or September 1961. Write Dept. of Machine Design, Upson Hall, Cornell University, Ithaca, N. Y.

ASSOCIATE PROFESSOR OF INDUSTRIAL Engineering, masters degree necessary, Ph.D. and/or P.E. desirable. Major interest and experience in production and operations research. Opportunity to succeed present department chairman in 1962, and to develop consulting practice. Prefer engineer with considerable industrial experience who would like to enter teaching as a career. Salary open. Mature engineer 40–55. North Dakota.

ELECTRICAL ENGINEERING. INstructor or Assistant Professor. M.S. degree is minimum requirement; Ph.D. is desirable. Emphasis on electro-mechanical and control systems. Computer interests desirable. Opportunities for curriculum development in new 5-year program. Excellent salary scale and fringe benefits. Apply to E. P. Nye, Professor of Engineering, Trinity College, Hartford 6, Connecticut.

ASSOCIATE OR FULL PROFESSOR to assume responsibility of directing the mechanical engineering division of Research Laboratories for the Engineering Sciences. Ph.D. required with 8 or 10 years experience in research. Part time graduate teaching available if desired. Apply to: Professor F. T. Morse, Chairman, Department of Mechanical Engineering, University of Virginia, Charlottesville, Virginia.

EXCELLENT OPPORTUNITIES available at San Jose State College in electrical and mechanical engineering beginning either February or September 1961. Appointments at Associate Professor level to qualified Ph.D.'s. Located in San Francisco Bay Area, center of expanding research, development, and manufacturing activities. Contact Norman O. Gunderson, Dean of Engineering, San Jose State College, San Jose 14, California.

ELECTRICAL ENGINEERING—Ph.D.'s or equivalent needed to implement a doctoral program in engineering. Electrical fields of interest are computers, advanced circuit theory, advanced communications, control engineering, and solid-state. Liberal employment policies and fringe benefits, excellent opportunities for research and graduate teaching, tremendous potential for development in a highly industrialized area. Write Frederic P. Fischer, Chairman, Electrical Engineering Department, University of Buffalo, Buffalo 14, New York.

ASSISTANT PROFESSOR OR INstructor preferably with an interest in gas dynamics to teach undergraduate courses in fluid mechanics and applied mechanics. Applicant will be expected to set up a research program in his field of interest and to contribute to the postgraduate instruction program. Good academic and research background desired, preferably with a Ph.D. Appointment September or later depending upon availability. Write Head, Department of Mechanical Engineering, University of British Columbia, Vancouver 8, Canada.

Announcement of Awards

Nomination forms for the awards listed below and a convenient form for summarizing information may be obtained from the Committee Chairman or from the Secretary of the Society, W. Leighton Collins, University of Illinois, Urbana, Illinois.

Lamme Award

The Lamme Award consists of a gold medal and bronze replica bestowed annually upon a distinguished engineering educator for excellence in teaching and contributions to research and technical literature; achievements which contribute to the advancement of the profession, and engineering college administration. The Lamme trust fund was established in memory of Benjamin Garver Lamme in 1928.

Preliminary nominations should be submitted by letter to the Chairman of the Lamme Award Committee, J. C. Calhoun, Jr., Texas A. & M. College, College Station, Texas, on or before January 1, 1961. Additional information should be mailed by February 1, 1961.

Vincent Bendix Award

This gold medal and citation are presented for outstanding research contributions, either in original thought or administrative leadership, to a staff member of an engineering college in the United States. The Award was established through the efforts of the ECRC and the Bendix Aviaiton Corporation.

Preliminary nominations should be submitted on or before January 1, 1961, to J. H. Rushton, Bendix Award Committee Chairman, Purdue University, Lafayette, Indiana. Additional information should be submitted by February 1, 1961.

Curtis W. McGraw Research Award

Primarily intended to recognize an outstanding young member of an engineering college research staff in the United States, the Award is limited to nominees who will be under 40 years of age on June 30, 1961. This prize, sponsored by ECRC with the assistance of the McGraw-Hill Book Company, consists of $1,000 in cash and an engraved certificate.

Preliminary nominations should be submitted to M. E. Forsman, Curtis W. McGraw Research Award Committee Chairman, University of Florida, Gainesville, Florida, by January 1, 1961. Additional information should be submitted by February 1, 1961.

George Westinghouse Award

This award was established by the Westinghouse Educational Foundation as an annual award to young engineering teachers of outstanding ability to recognize and encourage their contributions to the improvement of teaching methods for engineering students. It consists of $1,000 in cash and an engraved certificate. Nominations should be sent to the Chairman of the Committee, E. J. Lindahl, c/o ASEE, University of Illinois, Urbana, Illinois, by March 1, 1961, and they must be accompanied by documentary evidence supporting major statements and claims.

James H. McGraw Award

Each year the Technical Institute Division presents to an outstanding contributor to Technical Institute education this award. Established by the McGraw-Hill Book Company, the award consists of $500 and an engraved certificate. Nominations are to be submitted to the Chairman of the James H. McGraw Award Committee, M. W. Roney, Oklahoma State University, Stillwater, Oklahoma, by March 1, 1961.